

CATALOG No. 44

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» » SCIENCE « «

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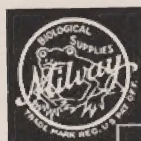
LABORATORY

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EQUIPMENT

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FOR  
PHYSICS, CHEMISTRY  
GENERAL SCIENCE  
AGRICULTURE AND  
BIOLOGY



ESTABLISHED 1908

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**CHICAGO APPARATUS COMPANY**

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1735-1743 NORTH ASHLAND AVENUE, CHICAGO, ILLINOIS

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President

C. A. BENGSTON,  
Treasurer

N. E. BENGSTON,  
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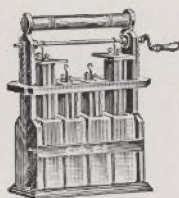
J. O. BENGSTON,  
Secretary

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No. 133E.



No. 148E.



No. 158E.



No. 165E.

### Grenet Batteries and Renewals

- 133E. Battery, Grenet.** Latest French type, pint size. On account of its convenience this cell is ideal for lecture table work. Gives a very powerful current for a short time. Initial E. M. F.—2 volts, low internal resistance. Height of cell, 8 inches. Complete without chemicals. (See Paragraph No. 7, Page 31) .....\$3.00
- 134E. Carbon Elements, with holder.** Per pair .50
- 135E. Zinc Element** .....Each .40
- 138E. Battery, Grenet.** Latest French type, quart size, 10 inches high. (See Paragraph No. 7, Page 31) .....\$4.00
- 139E. Carbon Elements, with holder.** Per pair 1.25
- 140E. Zinc Element** .....Each .45

### Le Clanche Battery

This type has been discontinued by the makers and can no longer be supplied. We recommend No. 165E Samson Battery as the most satisfactory substitute.

### Plunge Batteries and Renewals

- 148E. Battery, Plunge, Four Cells.** On account of its many advantages this is unquestionably the best battery for the lecture table. The cells may be used singly, in a series or in parallel. The initial output of each cell is about 10 amperes at 2 volts. The case is so designed that the elements may be readily lowered into or raised out of the solution. A dead-fall catch securely holds the elements at any desired height. The elements of any cells not needed may be suspended from the crank axle. Complete with case. (See Paragraph No. 8, Page 31).....\$25.00
- 150E. Carbon Plate only,**  $6\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$  inches.. .60
- 151E. Complete Element,** two carbon plates and zinc plate attached to fiber top with binding posts and hook .....\$2.75
- 152E. Glass Jar,**  $2\frac{1}{4} \times 4\frac{1}{4} \times 7$  inches..... .75
- 153E. Zinc Plate only,**  $6\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$  inches.... .50

- 158E. Battery, Plunge, Milvay, Single Cell.** An ideal battery for laboratory and lecture table work. Powerful and compact. Elements can quickly be lifted out of solution when not in use—see illustration. Fibre top with nickel-plated brass trimmings and large zinc and carbon elements; initial E. M. F., about 2 volts; internal resistance when freshly charged, 0.15 ohms. (See Paragraph No. 8, Page 31) .....\$4.50
- 160E. Battery, Plunge, Milvay, Four Cells.** In neatly finished wood case with metal handles. (See Paragraph No. 8, Page 31).....\$22.00
- 162E. Carbon Plate.** For Milvay Plunge Battery;  $4 \times 3 \times \frac{1}{4}$  inches .....\$0.35
- 163E. Glass Jar.** For Milvay Batteries;  $4 \times 4 \times 8$  inches .....\$0.75
- 164E. Zinc Plate.** For Milvay Plunge Battery;  $4\frac{1}{8} \times 3\frac{1}{4}$  inches .....\$0.60

### Samson Battery and Renewals

- 165E. Battery, Samson.** A durable and popular cell of the carbon cylinder type for open circuit work. Recuperates very quickly. E. M. F. 1.5 volts. Internal resistance about 0.7 ohms. Complete with chemicals. (See Paragraph No. 9, Page 31)....\$3.25
- 166E. Carbon** ..... 1.60
- 167E. Zinc Cylinder** ..... .75

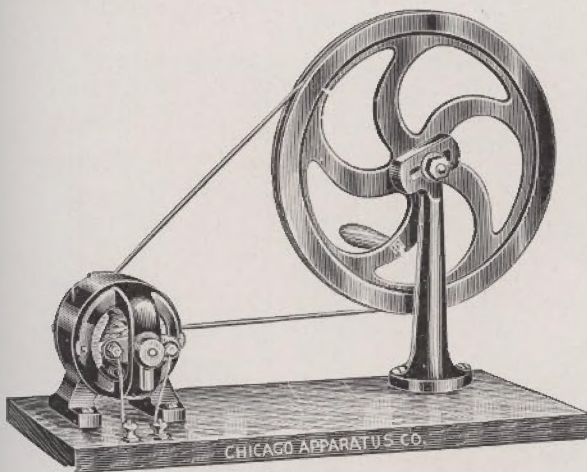


No. 168E.

### Simple Voltaic Cell and Renewals

- 168E. Battery, Simple Voltaic.** Consists of No. 633W Tumbler, No. 169E Copper Element, and No. 170E Zinc Element. (See Paragraph No. 10, Page 31) .....\$0.30
- 169E. Element, Copper, flat,**  $12.5 \times 2$  cm., with wire attached .....\$0.10
- 170E. Element, Zinc, flat,**  $12.5 \times 2$  cm., with wire attached .....\$0.10





No. 399E.

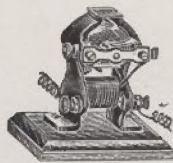
**399E. Dynamo, Hand Power.** An inexpensive model that yields highly satisfactory results in experimental and demonstration work. The dynamo closely resembles the large modern machines in general use. The drive mechanism is so proportioned that the maximum output—24 watts, 6 volts, 4 amperes—is easily obtained. This output is sufficient to operate induction coils, small motors, fans, electrolysis apparatus, electro-plating outfits, miniature lamps, etc. The armature is of the drum type, made of soft sheet iron laminations, six sections, carefully wound and shellacked. Field coils are form wound and well taped. Six section commutators of ample carrying capacity. Phosphor bronze brushes of the best quality. The head of the drive wheel support is slotted so that the tension of the belt can always be quickly adjusted to the best operating point. Two large binding posts on the base make it very convenient to connect accessory apparatus into the dynamo circuit. Complete as illustrated, on finely finished 20x45 cm. hardwood base.....\$25.00

**400E. Dynamo, Little Hustler.** Same appearance as No. 743E Motor, but wound especially as a generator.....\$2.50

**402E. Dynamo and Motor.** Consists of one No. 400E Little Hustler Dynamo and one No. 743E Little Hustler Motor mounted on a common base and connected as a Motor-Generator Set, so that the power developed by the motor is used to drive the generator, thus affording a nice illustration of the conversion of mechanical to electrical energy. The current output of the generator may be indicated on our No. 574E Portable Galvanometer.....\$6.00

**403E. Dynamo, K. & D.** Shunt wound to obtain best results as a generator. It will light to full power 12 6-volt, 3-candlepower lamps. For electro-plating purposes it will operate a five-gallon solution successfully. Finished in black enamel. Fitted with 1½-inch grooved pulley. Length of shaft, 6 inches. Weight, 9 pounds. Occupies space 6x4¼x6 inches. At speed of 2200 R.P.M. the output is 36 watts (6 volts, 6 amperes).....\$12.00

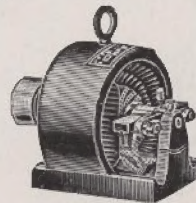
**405E. Dynamo, Plating and Charging Generator.** For electro-plating and charging storage batteries. Fitted with 2¼-inch flat pulley. Overall height, 6½ inches; length of shaft, 9 inches; weight, 23 lbs. Generates 77 watts—7 volts, 11 amperes; speed, 2000 R.P.M. A high grade shunt wound machine designed for continuous duty.....\$33.00



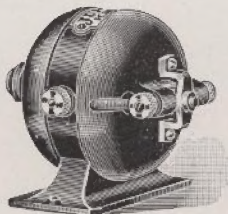
No. 400E.



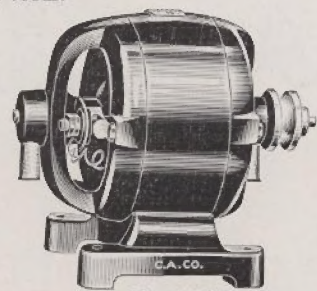
No. 402E.



No. 403E.



No. 405E.



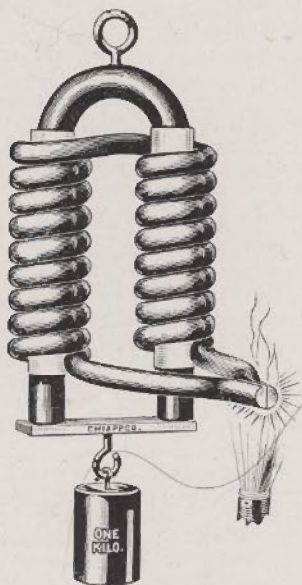
No. 408E.

**408E. Dynamo-Motor, D.C.** As a Dynamo it generates 16 watts, 8 volts, 2 amperes, at a speed of 2600 R.P.M. Well adapted for lighting miniature lamps, operating induction coils, running small motors, decomposing water, charging small storage batteries, electroplating, and any other work requiring a D.C. current not exceeding 8 volts and 2 amperes. As a Motor it develops good speed and power on two cells of battery and will be found useful in operating mechanical models, etc. In construction it closely resembles the larger commercial machines in general use. Field and frame are cast in one piece. Armature is of the drum laminated type, six sections, carefully wound and shellacked. Field coils are form wound and well taped. Commutator is of the six-section type. Fitted with 1-inch, V-grooved pulley for ⅜ to ⅝ inch round belting. Finished in black enamel. Height 4½ inches, weight 4½ pounds.....\$9.75

**409E. Dynamo-Motor, D.C.** Same as No. 408E, but for heavier duty. As a Dynamo it generates 32 watts, 8 volts, 4 amperes, at a speed of 2600 R.P.M. As a Motor it develops good speed and power on three cells of battery. This machine will do all that No. 408E does, but since it has double the output and double the power it will operate larger devices and give longer service. It has a 1-inch V-grooved pulley for ⅜ to ⅝ inch round belting. Height 5 inches, weight 5 pounds.....\$12.00

**410E. Dynamo-Motor, D. C.** Built along the same lines as Nos. 408E and 409E, but much larger. As a Dynamo it generates 100 watts, 10 volts, 10 amperes at 1800 R.P.M. As a Motor it develops 1/12 H.P. Very practical for lighting lamps having a total candle power of 150 or less, charging storage batteries and operating a great variety of other electrical devices and appliances requiring considerable current or power. It has 3-inch pulley for 1-inch flat belt. Height 6 inches, weight 16 pounds.....\$29.25





No. 500E.

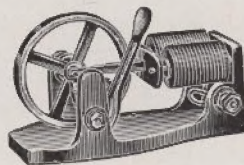
**500E. Thermoelectric Magnet, Milvay.** For effectively demonstrating thermoelectricity by the power it develops in a lifting magnet. The form follows closely that of the conventional electromagnet and is, therefore, easy and convenient to use. It responds quickly and produces striking results.

The thermocouple consists of two dissimilar metals of 10 mm. cross-section, brazed together to form a junction suitable for flame heating as illustrated. The other ends are riveted and fused to the terminals of two single-layer coils formed from heavy copper rod, also of 10 mm. cross section. Small spaces separate each turn. This construction, together with the insulation on the core, prevents all danger of short circuits between turns. The U-shaped core, of soft Norway iron, 16 mm. cross-section, is 15.5 cm. long and provided with suspension hook. The armature, also of soft iron, has a hook for the suspension of weights.

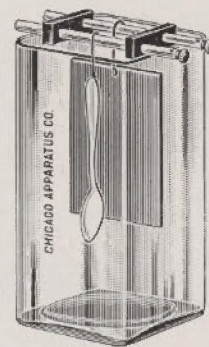
To operate, suspend the electromagnet from a suitable support and heat the junction in the flame of a Bunsen burner or, better still, of a Meker or other form of high-temperature burner. In about 30 seconds place the armature in position, which should then hold. In another 30 seconds attach a one-kilo hook weight to the armature hook. If the magnet does not now hold the weight allow the heating to proceed a little longer until it does. Other smaller hook weights may be added to determine the maximum weight-lifting power. The power of the magnet depends upon the intensity of the flame employed, and varies also to some extent in different magnets. Our tests on a large number of these thermoelectric magnets using our No. 495C Milvay burner for heating, showed the maximum lifting power to vary from 1.5 to 2 kilos, but to be conservative, we guarantee it to be at least 1 kilo.

Like an electromagnet, the strength of thermoelectric magnet depends upon the number of ampere turns, and this also depends upon the voltage, which in this case is the E.M.F. developed by the thermocouple upon heating. By the following method the ampere flow can be measured and the E.M.F.

calculated. Remove the U-shaped core, which can be done quite readily, and wind upon it 18 turns of No. 16 B. & S. insulated copper wire, 9 turns on each leg, as in the case of the coils removed. Send a current from a battery through this substitute or test coil that will just lift 1 kilo and, with an ammeter, measure this current. In an actual test this was found to be 9.5 amperes. Consequently, this same amount of current must be flowing when the thermoelectric magnet lifts this same weight. Since the resistance of the heavy copper coils is known to be .00045 ohm (450 micro-ohms), it follows from Ohm's law, that the E.M.F. developed by the thermocouple was .00428 volt (4280 micro-volts). Similar determinations and calculations can be made for other lifting powers. Complete, as illustrated, but without weights or burner .....\$13.50



No. 503E.



Nos. 508E-520E.

**503E. Electromagnetic Engine.** A simple mechanism showing a unique application of the electro-magnetic principle. A contact device makes and breaks the circuit during each revolution. This imparts a reciprocating motion to the armature which in turn rotates the crankshaft and its fly wheel. Provided with reversing lever. Runs well on one dry cell. Overall length, 12 cm. ....\$1.50

**508E. Electroplating Outfit, Copper.** Square glass jar with two brass rods for supporting anode and objects to be plated. To insure proper spacing and to prevent loss the rods are mounted in fiber bars. On their ends are binding posts for making connection with the source of current. Complete with copper anode, chemicals, 4x4x8" jar, and full directions .....\$1.75

**509E. Copper Anode Only for No. 508E.....\$0.25**

**510E. Chemicals Only for No. 508E..... .25**

**513E. Electroplating Outfit, Nickel.** Same as No. 508E, but with pure nickel anode, chemicals 4x4x8" jar, and full directions .....\$2.85

**514E. Nickel Anode Only for No. 513E..... 1.00**

**515E. Chemicals Only for No. 513E..... .35**

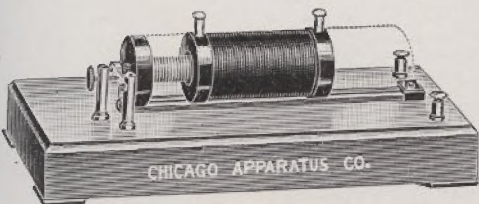
**505E. Electroplating Outfit, Silver.** Same as No. 508E, but with pure silver anode, chemicals, 4x4x8" jar, and full directions.....\$6.25

**506E. Silver Anode Only for No. 505E..... 3.50**

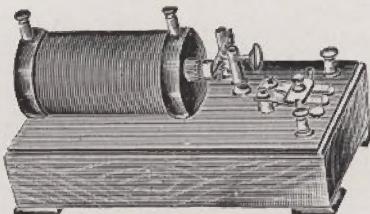
**507E. Chemicals Only for No. 505E..... 1.50**



Induction Coils



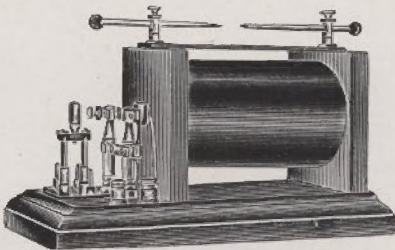
No. 638E.



No. 643E.



No. 650E.



No. 653E.

**638E. Induction Coils.** Demonstration form, with sliding secondary, on polished mahogany box with condenser; spark length, 6 mm.....\$7.00

**643E. Induction Coils.** Mounted on finely polished mahogany box, with commutator, condenser and adjustable vibrator or interrupter. Any of these coils will operate on the low voltage battery current produced by one to three cells. These coils are strictly high grade and guaranteed to give splendid results and long service.

Cat. No. ....	643E	645E	647E
Spark, length, mm. ....	6	13	25
Each .....	\$8.00	12.00	21.00

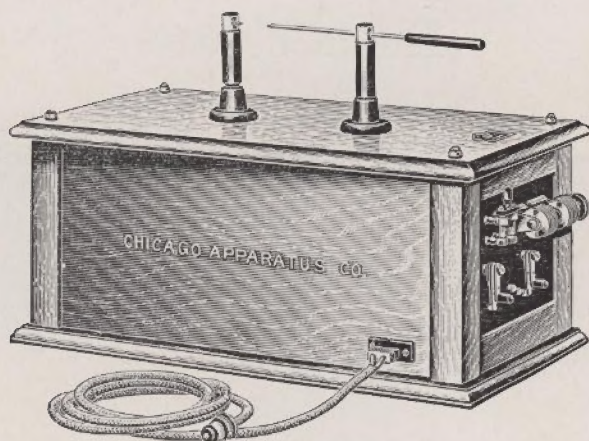
**650E. Induction Coil, 1-inch Spark.** A rugged, low-priced coil that will give complete satisfaction in the operation of Geissler Tubes, Spectrum Tubes, Wireless Transmitters, Spark timers, etc. Yields a heavy crashing spark 1 inch long when operated on a 6-volt storage battery or 5 to 6 dry cells. The primary and secondary coils are section-wound and imbedded in an insulating compound which completely fills the inside of the case. The vibrator is adjustable and the heavy breaker points are shunted

by a condenser to prevent excessive arcing. The secondary terminals, 3.5 inches apart, are located on top; the terminals for the current supply on the same end as the vibrator. The case is of finely finished oak and measures 21.5x10.5x12 cm. Metal parts are of brass.....\$9.00

**653E. Induction Coils.** Equipped with mechanical circuit breaker mounted independently on a heavy block of slate. The rigidity of this construction increases the efficiency of the coil. The secondaries are built in sections, each section being wound in layers. Three means of adjustment are provided, allowing a wide range of regulation—3 to 100 vibration per second. This makes the coil adaptable to a large variety of work. A double pole, double throw knife switch for reversing the direction of the primary current is mounted on the base. All operate on low voltage battery circuits, the 150 mm. coil delivering its maximum spark with an input of only 6 amperes at 4 volts (24 watts); the smaller coils take proportionately less.

Cat. No. ....	653E	654E
Spark, length, mm. ....	75	150
Each .....	\$50.00	85.00





No. 656E.

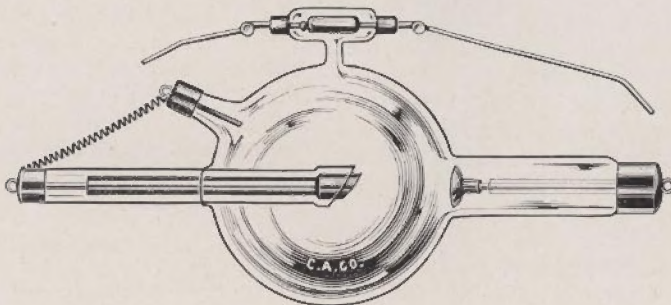
**656E. Induction Coil, 110-Volt A.C. operated, X-Ray and Demonstration Type.** Made especially for use by a leading manufacturer of medical X-Ray equipment. If a Tungsten Target tube of the type listed under No. 545F is employed, X-Rays of sufficient penetration are produced so that the bony structure of the Hand, Wrist, Elbow, Foot, Ankle, Upper Arm, Knee, Shoulder, Head, Chest, and Spine may be examined with a fluoroscope or photographed on suitable plates. In photographic work the exposures vary from 1 second for the Hand to 20 seconds for the Spine.

Upon a Bakelite panel at one end of the coil the following controls are mounted. Main switch for opening and closing the primary circuit. Tungsten Interrupter Points with adjusting knob for regulating the frequency and current flow. The points are equipped with copper flanges for air cooling. Rheostat lever for regulating the current flow through the tube. Frequency lever for regulating the frequency from Violet Rays to X-Rays.

The secondary terminals are mounted on insulating pillars, approximately 5 inches high. One terminal is a fixed point; the other, provided with insulating handle, is rotatable about the pillar as an axis. The maximum spark gap is about seven inches, and when the coil is operating at capacity a series of heavy sparks will jump across this gap, producing the sharp crackling noises characteristic of high-tension jump discharges.

The coil is designed to operate directly on a 110-volt A.C. circuit and has a maximum current draw of 16 amperes. The primary and secondary windings are embedded in insulating wax and enclosed in a finely mahogany-finished case. Length 26 inches, width 16 inches and height, exclusive of secondary pillars, 17 inches. Complete with seven-foot detachable cord provided with two-piece attachment plug and full directions .....\$125.00

**545F. X-Ray Tube, Tungsten Target Type, 6-inch Diameter.** Especially pumped for use with our No. 654E or 656E X-Ray Coil. Remains cooler and maintains a more constant vacuum than tubes of smaller diameter. Also for these reasons it will not require vacuum reduction treatment as frequently as the smaller sizes. The chamber to which the long slender wire terminal is attached is filled with asbestos, treated with a chemical which vaporizes into a gas by the passage of a current. By adjusting the slender wire so that its terminal is within one inch of the cathode terminal and passing a spark for a second or two the internal resistance of the tube is lowered. This reducing treatment is only necessary when the vacuum in the tube becomes too high, as it will after considerable use. This heavy Tungsten target type tube is identically the same as that used in professional medical work where results and service are paramount to a small difference in cost .....\$38.50



No. 545F.





No. 146F.

**146F. Fluoroscope, Professional Type.** The brilliant results obtained in X-Ray examinations with this fluoroscope are due to the remarkable characteristics of its screen: 1. The fluorescent salt from which the screen is made is an absolutely stable chemical combination and is not affected by heat or dampness, by the continual bombardment of X-Rays, or by pressure. It does not deteriorate with age, like the barium platinum-cyanide screens so quickly do. 2. The light emitted by this screen is brilliantly white. The images therefore present black and white contrasts which are pleasing to the eye. 3. The screen is free from visible grain. This is a most important attribute as it assures images with sharp clean-cut outlines. 4. It has absolutely no phosphorescent afterglow or lag. This quality prevents blurred outlines when examining moving objects.

Expert Roentgenologists use this type regularly for the fluoroscopic examination of fractured bones, etc. Used with our No. 656E Induction Coil and No. 545F X-Ray Tube, because of the penetrating X-Rays produced by this equipment, this fluoroscope reveals the bony structure of the Hand, Wrist, Elbow, Foot, Ankle, Knee, etc., with a contrast, sharpness, and clearness impossible with calcium tungstate or barium-platinum-cyanide-screen-equipped fluoroscopes. The screen, 5x7 inches, is covered by a glass plate on the inside to protect it from dust and is readily removable for examination or replacement. It is mounted in a finely finished box with handle and fur-lined eyepiece.....\$26.50

**657E. High Frequency Tesla-Type Coil.** Operates directly on 110 volts A.C. or D.C. without the use of rheostats. Produces a stream of high potential, high frequency sparks, about 2 inches long, that pass out continuously from the metal tip into the surrounding air or to nearby objects of metal. Consists of a special Tesla type high frequency generator with one secondary terminal connected to a long pointed metal tip. At the opposite end is a six-foot cord with plug and a screw for quickly adjusting the discharge to maximum. The entire unit is enclosed in a black bakelite cylindrical shell. Because of the high insulating quality of the latter, no discharge can escape except by way of the metal tip. Therefore, the coil can be safely handled and



No. 657E.

its discharge directed to wherever desired. It is this portable feature, together with its fine performance, that makes it ideal for many laboratory and demonstration purposes. A few of its more important uses are:

**Exciting Vacuum Discharge Tubes.** It will operate practically every type of vacuum tube—Geissler, spectrum, aurora, Holtz, Hittorf, shadow cross, fluorescent, phosphorescent, etc. Most tubes will exhibit all their characteristics—glow light, fluorescence, phosphorescence, etc.—when the metal tip of the coil is brought to within several inches of either of its terminals. In some cases it may be necessary to bring the tip into actual contact with the terminal to secure the best effects. Then too, the second terminal may be grounded by attaching a chain or wire and allowing the free end to touch the table top. In any event the best method can always be quickly found by trial. The full beauty of tube effects is of course always revealed to the best advantage in the dark.

**Exciting Vacuum Tubes in a High Potential, High Frequency Field.** Insulating Stands No. 3105E with Screens No. 3115E mounted upon them are separated about ten inches, the screens being parallel to each other. One stand is grounded by attaching to its hook a chain or wire, the free end of the latter touching the table top. When the metal tip of the coil is brought into contact with the hook of the other stand, a high potential, high frequency field is set up between the screens. And, when any vacuum tube is brought into this field, it glows, fluoresces, and phosphoresces even though there is no connection of any kind to the terminals of the tube. Since a neon tube (our No. 3155E or No. 338F) is extremely sensitive to high tension fields, it may be used to explore the extent of the field between and around the screens. When the Electrodeless Tube No. 3155E is employed the effect produced is striking in the extreme.

**Detection of Leaks in Glass Vacuum Lines and Vessels.** The tip of the coil is moved along the tube or vessel to be examined, and at the point of puncture, the spark will pass through the minute hole in the glass wall, producing a distinct yellow glow. Workers in research laboratories and manufacturers of incandescent lamps, radio tubes, x-ray tubes, neon signs, vacuum bottles, etc., have used this method of locating leaks in vacuum systems and vessels with great success for many years.

Other uses for this portable high tension generator will readily suggest themselves, once the operator has become familiar with its performance. Overall size, about 5x27 cm. Complete with cord and plug .....\$15.00



## Tesla High Frequency Coil

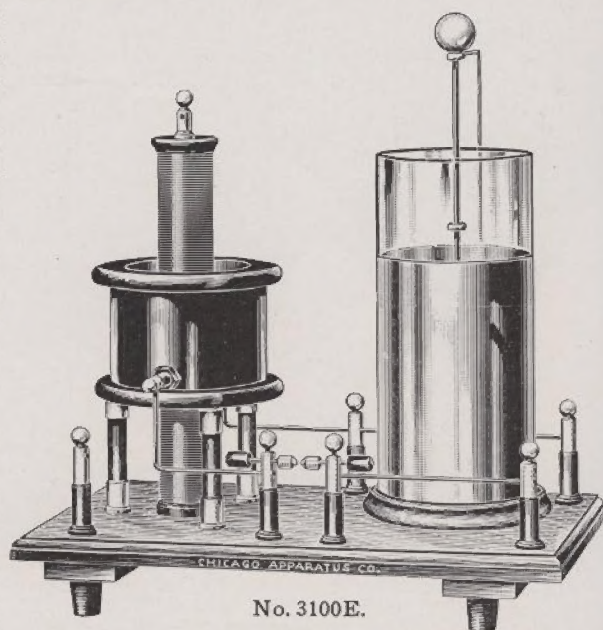
**3100E. Tesla High Frequency Coil or Oscillation Transformer, Milvay.** For generating high frequency and high voltage currents with which many spectacular demonstrations can be made. The apparatus consists of a primary coil, having a few turns of heavy copper wire, connected in series with a Leyden jar and an adjustable zinc spark-gap. Co-axially within the primary coil is a secondary coil having a large number of turns of fine wire brought out to two large brass terminals with ball-topped screws. One of these terminals is located at the top of the coil, the other on an insulating pillar in a near-by corner of the base. The primary coil is enclosed in an insulating housing, and the connections from this coil to Leyden jar and spark-gap are heavy brass rods elevated on tall insulating posts, a construction which entirely prevents leakage of the high tension currents flowing through this circuit.

In use, the secondary terminals of an induction coil with a spark output of 3 to 6 inches (Our No. 653E or 654E) or of a transformer (Our No. 1039E) is connected to the primary terminals of the Tesla Coil. This produces a succession of spark at the zinc spark-gap, each spark giving rise to a group of high frequency oscillations in the secondary windings, resulting in remarkable brush discharge and other effects at the secondary terminals. The extremely high potential in the secondary of the Tesla Coil is the result of the superposition of two oscillations having the same amplitude but differing in frequency. The gap yielding the best results for a given spark input is quickly found by trial.

Some of the spectacular demonstrations possible with this apparatus are:

**Brush Discharge Between Concentric Rings.** The secondary terminals of the Tesla Coil are connected, by chains or wires, with the hooks of No. 3105E Insulating Supports on which are surmounted No. 3110E Rings. The stands are shifted to bring the smaller ring concentrically into the plane of the larger ring which measures about six inches in diameter. On exciting the Tesla Coil, numerous heavy sparks will crash through the air between the rings. As the rings are moved 3 to 4 inches apart, the heavier sparks fade into a brush discharge which completely surrounds both rings and fills the space between them with myriads of reddish streamers and a beautiful reddish-violet glow light. The effect demonstrates the exceptionally high potential output of the Tesla Coil in a manner that is impressive and striking in the extreme. The effect is accompanied by the production of a tremendous volume of ozone.

**Brush Discharges Between Parallel Rods.** The rings are replaced by No. 3110E Rods. The stands are shifted so that the rods form a gap several inches wide. If the gap is parallel numerous heavy sparks will dance between the rods. As the size of the gap is increased, the sparks become fainter and more numerous. When the rods are separated so that no sparks will pass between them, each will become completely enveloped by a reddish-violet glow light, while numerous fine streamers pass into the surrounding air. If the rods are adjusted to form a narrower gap at the bottom than at the top, the so-called "Jacob's Ladder" effect can be produced. The discharge starts across the narrow gap at the bottom, climbs to the top, ceases, and then



automatically starts another climb from the bottom again. This climbing action is due to the fact that the spark produces and follows an ionized gas track that is carried upward by the convection currents resulting from the heat liberated by the spark. In the dark, the spark has the appearance of climbing an invisible ladder. The effect is extremely interesting and very striking.

**Figures in Glow.** No. 3120E or No. 3122E Figure Plate is mounted on one of the No. 3105E Stands. One Tesla secondary terminal is connected to the hook of the stand, the other to the binding post of the Figure Plate. In the dark, under the Tesla discharge, the outlines of the figures are revealed in a sheath of soft bluish glow light, producing a most beautiful and pleasing effect.

**Lighting Lamp by Current Induced in a Two-Turn Coil.** The secondary coil, which is the long slender coil within the larger primary coil, is removed. This is done by merely pulling it out of its slip socket. The primary coil is now approached by the No. 3125E Two-Turn Coil with lamp, the latter being an ordinary 6-volt incandescent bulb, and if the Tesla Coil is excited as usual, the lamp will glow, its luminosity depending upon its position in the field about the primary coil. In this experiment the Two-Turn Coil functions as a secondary with respect to the Tesla Primary, showing that the current through the Tesla Primary and the field surrounding it are alternating in character. This same alternating field induces the high potential currents in the Tesla Secondary, showing that, basically, the Tesla Coil operates in the same manner as an ordinary A.C. transformer.

**Electrodeless Vacuum Tube in a High Potential Field.** The terminals of the Tesla coil are connected to the hooks of No. 3105E Insulating Stands on which the No. 3115E Circular Screens are mounted. The stands are shifted so that the screens are parallel and about ten inches apart. The Tesla coil dis-



## Tesla Coil—Cont.

charge produces a high potential field in the space between the two screens: And, when No. 3130E Vacuum Tube, which has no electrodes, is placed in this field, it exhibits a soft bluish glow which fills the entire tube. In addition, portions of the glass walls exhibit greenish fluorescence. This demonstration is extremely striking when presented in the dark.

**Electrodeless Neon Tube in a High Potential Field.** The tube, No. 3135E is 50 cm. long and when brought into the high potential field, formed between the mounted screens as explained in the preceding paragraph, glows with a vivid reddish light which completely fills the tube. By moving it to various points in and about the screens, the extent and varying intensity of the field is revealed, for within certain limits the luminosity of the tube is proportional to the intensity of the field. Further, when the field becomes too weak, the glow ceases entirely. This tube is also valuable for exploring the fields about the input coil, the lead wires, leakage paths along the table top, etc. In the dark, it makes possible a most striking demonstration. Held in one hand by the narrow stem, it is moved back and forth through the field, between the screens, with a swift, even motion. To an observer, the motion of the tube seems to have been arrested every inch or so of its swing, and he sees six or seven images, each displaced by several degrees, instead of just a single image. The fact is the tube alternately lights up and goes out, but the periods of light and dark, follow so rapidly that, due to persistence of vision, this is not noticeable when the tube is still or moves slowly. However, when the tube is moved rapidly, only the positions it occupied when lighted are revealed, hence its apparent jerky motion. We know of no finer, simpler, nor more effective way of demonstrating the intermittent or oscillating character of high potential discharges and fields.

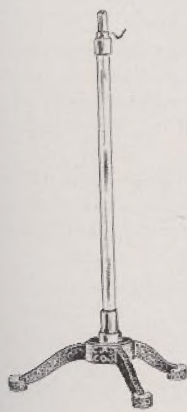
**One Electrode Vacuum Tubes.** These also fluoresce, phosphoresce and glow when placed in the high potential field described above, even though no connection is made to their single terminal. However, when one secondary terminal of the Tesla Coil is connected to the terminal of the tube, by a wire or chain, it is excited by a brush discharge, and its action varies depending upon whether the discharge is negative or positive. Then too, it also varies from the field excitation mentioned above. The effects are best visualized in the dark.

**Two Electrode Vacuum Tubes.** Every type of vacuum tube, Geissler, spectrum and special, can be operated in the high potential field already mentioned, without any connection to their electrodes. Likewise, they can also be operated by connections with wire or chain, to either or both of their electrodes. In many cases, there is a marked difference due to the method of excitation. In every case, the results are extremely beautiful, striking and interesting.

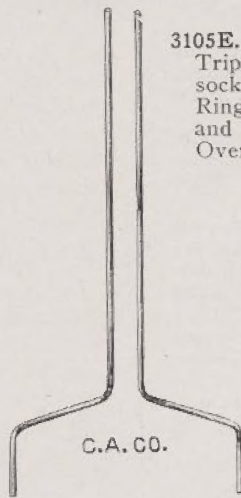
The foregoing experiments are only a few of the many spectacular things that can be done with this Tesla Coil. Variations therefrom and others will readily suggest themselves as the operator becomes familiar with the performance of the coil and the behavior of the accessories mentioned above. The design of the Milvay Tesla Coil is such that all complicated adjustments have been eliminated. It is only necessary to connect it to the secondary of a suitable induction coil or transformer and to vary the Tesla spark-gap to secure fine results. The spark-gap will give some result no matter how large or small it may be, hence the adjustment, which is not critical, to secure the best results, is quickly and easily made. The apparatus is made from selected materials and is finely finished. It stands 50 cm. high overall. As illustrated, but without any of the accessories listed below.....\$75.00

## TESLA COIL ACCESSORIES

The striking demonstrations possible with the following accessories is told in detail in the foregoing description of the Milvay Tesla Coil.

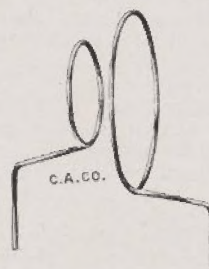


No. 3105E.



No. 3110E.

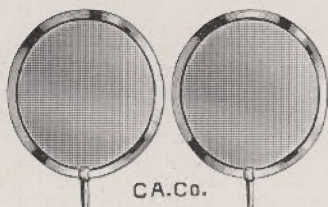
**3105E. Insulating Stands, High Frequency Type.** Tripod base; with glass column carrying a brass socket at its upper end for receiving No. 3110E Rings and Rods, No. 3115E Screens, and Nos. 3120E and 3122E Glow Figures; and hook for connection. Overall height, 40 cm.....Per pair \$8.00



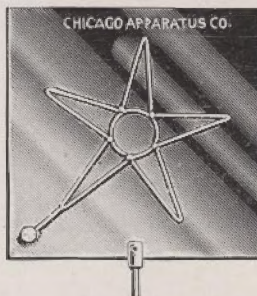
**3110E. Concentric Rings and Rods for Brush Discharge.** To fit on No. 3105E Stands. The larger ring is 15 cm. in diameter and the rods are about 42 cm. high. Made from heavy brass rod. Set consists of two rings and two rods ...Per Set \$4.00



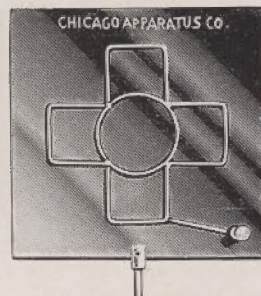
## Tesla Coil Accessories—Cont.



No. 3115E.



No. 3120E.



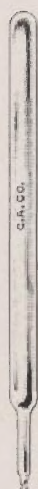
No. 3122E.



No. 3125E.



No. 3130E.



No. 3135E.



No. 3140E.



No. 3145E.

**3115E. High Potential Field Screens.** To fit on No. 3105E Stands. Wire net surface with solid brass ring to provide metallic contact with all wires in the screen. Diameter, about 15 cm. ....Per Pair \$6.50

**3120E. Glow Figure, Star-Shaped.** To fit on No. 3105E Stands. On 22x22 cm. heavy hard rubber plate .....\$7.50

**3122E. Glow Figure, Cross-Shaped.** To fit on No. 3105E Stands. On 22x22 cm. heavy hard rubber plate .....\$7.50

**3125E. Two-Turn Coil with Lamp.** Two turns of heavy, insulated wire with socket and lamp for revealing the inductive action of the Tesla primary circuit .....\$5.00

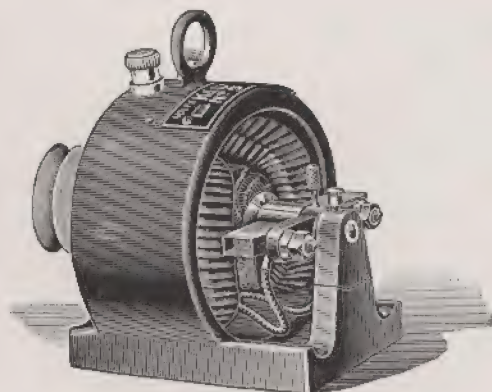
**3130E. Electrodeless Vacuum Tube.** A highly evacuated globe-shaped tube exhibiting glow and fluorescent effects in a high frequency, high potential field. On wooden support. Overall height, 35 cm. ....\$5.00

**3135E. Electrodeless Neon Tube.** A highly evacuated neon tube that glows with a vivid reddish color when brought into a high frequency, high potential field. Size, about 50x3 cm. ....\$6.00

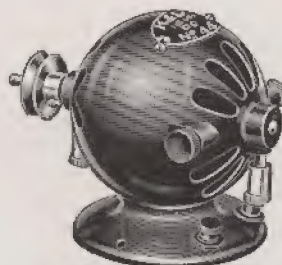
**3140E. Vacuum Tube with Phosphorescent Cross.** A highly evacuated tube with one electrode and cross, the arms of which are coated with various phosphorescent minerals. When excited by a Tesla discharge, the tube is filled with a bluish glow, portions of the glass exhibit greenish fluorescence, while the cross contributes the several different kinds of colored phosphorescence characteristic of the minerals with which it is coated. The whole presents a most striking effect, which is greatly enhanced in the dark. On wooden support. Overall ht., 39 cm..\$8.50

**3145E. Vacuum Tube with Phosphorescent Mineral.** A highly evacuated tube containing a mineral that exhibits a distinct fiery red phosphorescent glow when excited by a Tesla discharge. It continues to glow for a brief period after the excitation has ceased, showing that it is of the strongly phosphorescent class. During excitation, the tube also fills with a bluish light and portions of the glass exhibit brilliant green fluorescence. The whole effect may be visualized to the best advantage in the dark. On wooden support. Overall height, 25 cm....\$7.50





No. 2710E.



No. 2715E.



No. 735E.

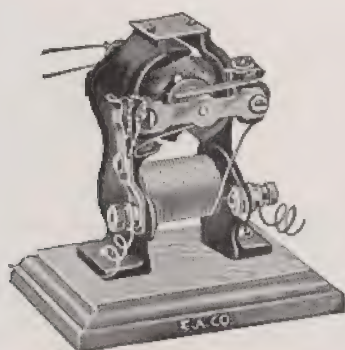
**2710E. Motor, K. & D., Power. Battery type.** This machine is designed for actual work. It is designed on the lines of large machines and is constructed with care in every detail. The field is of the ring type, cast solid with the frame; coils are form wound. The armature is of the drum type, having 6 sections; it is laminated, best charcoal iron being used for the disks. The commutator segments are of hard copper, carefully insulated with mica. The brush holders are of the radial type on an adjustable yoke. The brushes are of woven wire and are self-adjusting. Finished in black enamel. Speed 1800 R.P.M. on a current of 2 amperes, 6 volts, with average load. Weight, 9 pounds. Length of shaft, 6 inches; diameter  $\frac{1}{4}$  inch. Grooved pulley  $1\frac{1}{2}$  inches in diameter .....\$12.00

**2715E. Motor, K. & D. Universal type.** For use on 110-volt A.C. or D.C. circuits. High grade construction throughout. Speed with average load, 2000 R.P.M. Shaft  $\frac{3}{8}$  inch with 1 inch grooved pulley. Space occupied,  $4\frac{3}{4} \times 3\frac{1}{4} \times 3\frac{3}{4}$  inches. Will develop 1/50th horsepower and will not heat up when operated continuously on either kind of circuit.....\$10.50

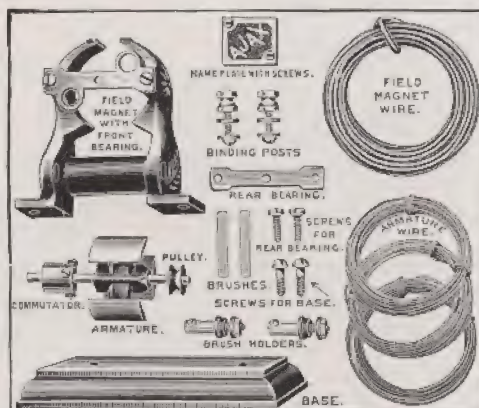
**735E. Motor, Universal.** Operates efficiently on either 110 volt D.C. or A.C. (60 cycle) current and develops about 1/50 H.P. The pulley is  $\frac{3}{4}$  inches in diameter and is V-grooved for  $\frac{1}{8}$  to  $\frac{3}{16}$  inch round belting. Fields and armature are laminated, and the latter is equipped with a heavy copper multi-section commutator, while the brushes are the finest quality spring-tension carbon type— $\frac{1}{4}$  inch diameter. The substantial construction and provisions for oiling and ventilation prevent this motor from heating up, even if operated continuously over long periods. It weighs 4 lbs., is  $6\frac{1}{4}$  inches high, consumes but 0.25 amperes, and is finely finished in black enamel. Complete with cord and plug.....\$9.50

**735Ed. Prony Brake Belt.** For use with Nos. 732E, 733E, 2710E, 2715E, or 735E Motors. Of  $\frac{3}{8}$ -inch round belting, with chain links at both ends for convenience in varying the effective length. Overall length, 27.5 inches .....\$0.60  
Dynamometers are listed on pages 52 to 55.

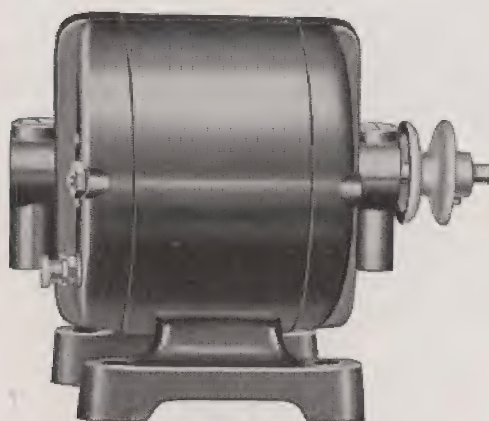




No. 743E.



No. 748E.



No. 755E.

**743E. Motor, Little Hustler.** Will run at high speed on one No. 113E Dry Cell or on a 110-volt A.C. Circuit through a No. 1033E Transformer. This motor is  $3\frac{1}{2}$  inches high, finished in black enamel, with nickel-plated trimmings. Has three-pole armature, causing the motor to start without assistance when the current is applied. The shaft,  $\frac{1}{8}$  inch in diameter, is fitted with a pulley for running toys, models, etc., and will drive No. 753E Fan at high speed. . . . \$2.00  
Dynamo, Little Hustler, is listed on Page 55.

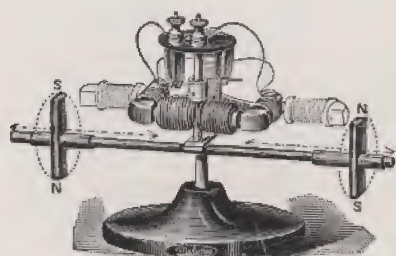
**748E. Motor Parts, Little Hustler.** These parts will enable the student to construct his own motor and thus demonstrate the principles he has learned. All parts ready to assemble into a finished motor like No. 743E. Explicit directions showing how to wind and assemble accompany each set. . . . . \$2.00

**755E. Motor, A.C., 110 Volt.** A low-priced power motor for general laboratory use. Operates on any 110-volt, 60-cycle alternating-current lighting circuit. Develops 1-25 horse power. Speed 3600 R.P.M. The construction follows standard commercial design for heavy duty and continuous service; Two-pole laminated field; eleven-slot laminated arma-

ture; eleven-segment, mica-insulated commutator;  $\frac{1}{4} \times 5\frac{1}{8}$  inch shaft; 1-inch, V-grooved pulley for  $\frac{3}{8}$  to  $\frac{1}{4}$  inch round belting; wick-feed oil cups. Height  $4\frac{1}{2}$  inches, weight  $4\frac{1}{2}$  pounds. . . . . \$12.00

**756E. Motor Parts, A.C., 110 Volt.** These parts will enable the student to build a 1-25 H.P. A.C. motor exactly like No. 755E illustrated and described above, thus demonstrating the principles he has learned. Requires very little skill to wind and assemble, and when finished is a perfect working machine that will run on any 110-volt—60-cycle—alternating current lighting circuit. All castings are finished. Armature discs are assembled on the shaft. Commutator, brushes, wire, screws, pulley, and all other necessary parts are included. The assembly of this Set of Parts will give students the same insight into A.C. motor principles, design, and construction that the No. 748E Set of Parts has for so many years given in the case of the D.C. motor. Although only recently introduced these outfits have already been used successfully in the Physics and Electrical Departments of numerous schools. Complete directions come with each set. . . . . \$9.50

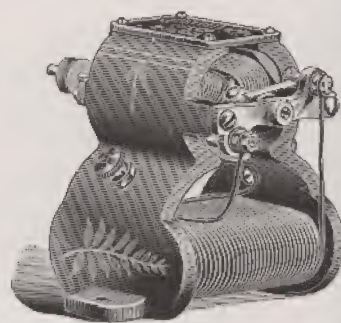




No. 758E.



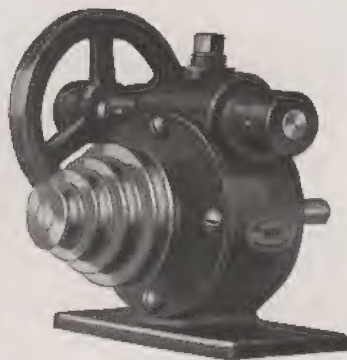
No. 763E.



No. 768E.



No. 770E.



No. 771E.

**758E. Motor, Milvay.** An improved form of St. Louis Motor for use in the study of motor and dynamo principles. The following points, which cannot be shown with an ordinary motor, can be shown to good advantage with the Milvay motor. The top, which carries the brushes, can be rotated to show the effect on the speed by changing the point of commutation. The permanent field magnets can be moved away from the armature to show the effect on speed by increasing and decreasing the gap between the field and armature. The same point can be shown with the electromagnetic field magnets. By connecting a rheostat (No. 918E) into the battery circuit the effect on the speed when the resistance is increased or decreased may be observed. By reversing the permanent field magnets the effect on direction of rotation may be shown. By moving the permanent field magnets out of the way and connecting the electromagnetic fields in parallel with the armature, the characteristics of a Shunt-wound motor may be studied. Connecting the electro-magnetic fields in series with the armature, the characteristics of the Series-wound motor may be observed. Swinging the electromagnetic fields out of the way, moving the permanent magnets back into place, and connecting a galvanometer (No. 523E) to the binding post terminals, in place of the dry cell, the characteristics of a dynamo may be studied. Every part is easily accessible and always completely visible. This makes it easy to test the polarity of either end of the armature core, as well as of the field magnets. Runs at high speed on one dry cell or other battery. Complete with both permanent magnets, electromagnets and full directions .....\$5.00

**763E. Motor, Standard, No. 1.** This motor is designed to run on a single cell, although two may be used if desired. If two are used, they should be con-

nected in series. The motor develops sufficient power to propel mechanical toys, models and other similar devices. Finished in black enamel, nickel-plated trimmings. Weighs about 1½ pounds; occupies a space 3½ inches square. Speed, with average load, about 2,200 R.P.M. ....\$4.25

**768E. Motor, Standard, No. 2.** Similar to No. 763E, but larger and heavier with corresponding increase in efficiency. Designed to operate on a two or three cell battery. Finished in black enamel, brass trimmings. Weighs about 2¾ pounds; occupies space about 4 inches square. Runs at about 2,800 R.P.M. with average load on a current of 2 amperes, 4 volts .....\$7.25

**769E. Countershaft.** For screwing to table, bench, baseboard, or other flat surface. Shaft, 12x¼ inches, is mounted in two end bearings and is parallel and about 3 inches above the base. On this shaft are 4-grooved pulleys—1, 2, 3 and 4 inches in diameter. These pulleys may be shifted along the shaft to any desired position and are held in place by set screws. Used in belting small motors and engines to other machinery .....\$3.25

**770E. Speed Reducing Gear.** For converting the high speed of motors into a slow, powerful motion. The round plate (shown at the left in illustration) may be removed if desired, and direct connection made to shaft. This round plate is provided with screw holes for attaching a large wooden disk used for display and other purposes. Diameters of (front) driving pulley—2, 3 and 4 inches. Diameters of (side) driven pulley—2 and 4 inches. Both are grooved for ⅜ or ¼-inch round belt. Worm and gear mechanism have a reduction ratio of 48 to 1, that is the 3 grooved pulley will make 48 revolutions, while the 2 grooved pulley makes one. Base has four screw holes. The action of this gear is not reversible; it can only be operated (in either direction) by applying power to the 3-groove drive pulley ....\$9.00

**771E. Speed Reducing Gear.** In this device the worm and gear mechanism are enclosed in a case filled with grease. As a result all bearings are self-lubricating. Runs silently and requires little attention. Diameter of (back) driving pulley, 4 inches. Diameter of (front) driven pulley, 1, 1½, 2 and 2½ inches. Worm and gear mechanism have a reduction ratio of 48 to 1, that is the single-grooved drive pulley will make 48 revolutions while the 4-grooved pulley makes one. Both are grooved for ⅜ or ¼-inch round belt. Base has four screw holes. The action of this gear is not reversible; it can only be operated (in either direction) by applying power to the single-grooved drive wheel. ....\$14.00



**2960E. Polarity Indicator.** Consists of two electrodes sealed into a glass tube filled with a chemical solution. When connected into a circuit the solution about the positive electrode turns red while that about the negative remains uncolored. Useful in determining the polarity of circuit terminals and the direction of current flow. Mounted in protective housing. For use on D.C. circuits up to 50 volts. **\$3.00**

**2965E. Polarity Indicator.** Same as No. 2960E, but for use on D.C. circuits from 50 to 600 volts. **\$3.00**

**2966E. Pole Indicating Paper.** Negative pole shows red stain where two terminals are placed close together on a piece of this paper, moistened. Book of 25 (7x1 cm.) strips. **\$0.15**

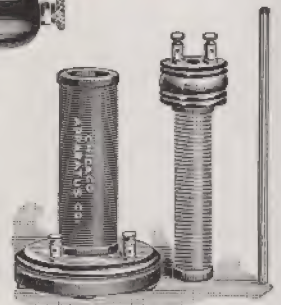
**793E. Primary and Secondary Coil.** For the study of current induction. The large number of windings on the secondary insures positive results. Mounted on two hardwood spools, the outer one provided with a base, the inner one removable. The inner spool (primary) is wound with a few turns of coarse wire,



Nos. 2960E-2965E.



No. 808E.

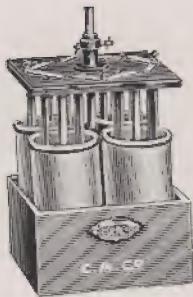


No. 793E.

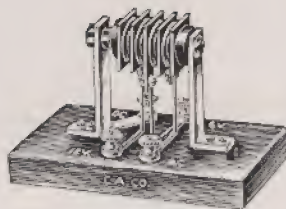
the outer (secondary) with many turns of fine wire. Each coil is provided with suitable binding posts. Total height about 20 cm. Complete with soft iron core **\$4.25**

**808E. Push Button, Wood.** Regular size, with screw top, diameter 55 mm. **\$0.15**

## Rectifiers — Battery Chargers



No. 818E.



No. 815E.

**818E. Rectifier, Electrolytic (Nodon Valve).** For use on 110 or 220 volt A.C. circuits to give a unidirectional current adapted to the needs of certain laboratory work—electrolysis, electroplating, charging of storage cells, etc. The action of this rectifier is due to the fact that an electric current will not enter an electrolyte from an aluminum electrode, but will do so freely from a lead electrode. The electrodes—eight 7x25 cm. lead plates and four 2x25 cm. aluminum rods—are attached to a substantial non-conducting top. The top connections are metal bars provided with binding posts for connecting into the A.C. line and for tapping off the D.C. current. The 75 cm. support rod in the center is for supporting the electrodes when raised out of the solution, in which position it is advisable to keep them when not in use. Small currents—5 to 10 amperes—may be drawn from this rectifier for hours at a time; large currents for proportionately shorter periods. Complete with hardwood box, 75 cm. support rod, four jars, chemicals, and full directions. **\$25.00**

**819E. Chemicals for No. 818E.**

Per complete charge **\$0.50**

**815E. Rectifier Unit, Dry Plate Type.** Because of its many advantages—compactness, ruggedness, non-breakability and adaptability—dry plate rectifier units are extensively employed in the operation of dynamic speakers, railroad signaling devices, electric time clocks, battery chargers, radio power packs, etc. Being a concealed, built-in part which operates smoothly and silently, its presence is seldom realized and its function little appreciated.

To afford schools an opportunity to study and test the performance of this marvelous device we offer a full-wave standard commercial unit suitably mounted and provided with convenient terminals.

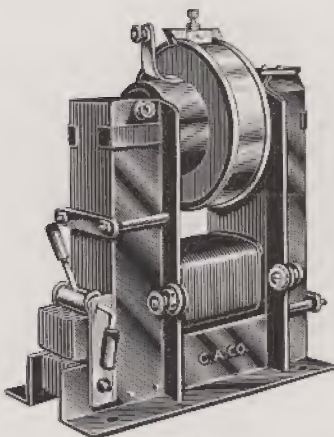
In use, an A.C. current of 9 to 12 volts is impressed on the A. C. terminals. The resulting E. M. F. at the D. C. terminals varies from 6 to 7.5 volts and the output from 0.25 to 2 amperes. This D.C. output may be used to operate bells, small motors, lamps, electromagnets, etc. It is also excellent for charging 6-volt storage batteries. Our No. 1033E or 1034E transformer is an excellent source of low voltage A. C. current for operating this rectifier unit.

By varying the A. C. input voltage and the D. C. current draw and employing meters in both circuits data can be secured which when plotted will accurately reveal the performance characteristics of the unit. Such a performance test is bound to prove interesting and profitable to students in electrical and radio courses.

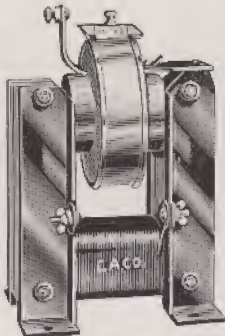
Mounted on 10x15 cm. hardwood base with plainly marked terminals as illustrated. **\$6.50**



Transformers—Cont.



No. 1039E.



No. 1040E.

**1039E. Transformers, Step-Up.** For use in high frequency experiments, wireless, insulation testing, etc. Standard air-cooled spark transformers of the resonant type, with double resonant magnetic circuit, one variable by means of a movable tongue. This so-called magnet shunt provides full protection against undue current surges. The primary is designed to be connected directly to an alternating current source, no resistance or impedance coil being necessary. Finished in black enamel with nickeled terminal posts.

No. ....	A	B	C
For use on alternating current of, volts .....	110	110	110
Designed for current frequency of, cycles .....	60	25	60
Rating of secondary, volts.....	10,000	10,000	25,000
Capacity, kilo-volt-amperes (KVA) .....	1/2	1/2	1
Shipping weight, lbs. ....	38	48	62
Each .....	\$22.00	28.00	40.00

**1040E. Transformers, Step-Up.** For use in high frequency and wireless experiments. Non-resonant type, differing from No. 1039E only in that these do not have the magnetic shunt control. The secondary is protected by an aluminum band or corona shield. For direct operation from alternating current source. Finished in black enamel with nickeled terminal posts.

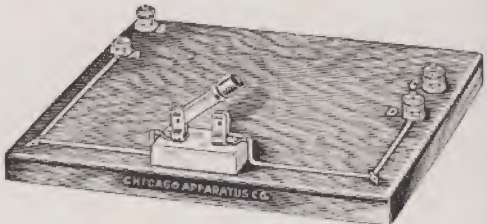
No. ....	A	B
For use on alternating current of, volts .....	110	110
Designed for curr. frequency of, cycles .....	60	25
Rating of secondary, volts.....	8000	8000
Capacity, kilo-volt-amperes (KVA) ..	1/4	1/4
Shipping Weight, lbs.....	15	20
Each .....	\$10.00	13.50



No. 1043E.



No. 1046E.



No. 1050E.

**1043E. Voltmeter, Copper (Coulombmeter), Milvay.** For measuring current flow by electro-chemical effect. The three plates—one gain and two loss—are locked against the under side by three screws passing through the top. A turn of these screws releases the plates and eliminates touching them with the fingers. Area of each plate about 35 cm. Complete with glass jar .....\$3.50

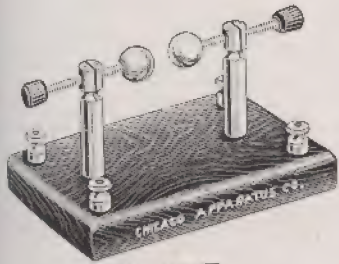
**1044E. Voltmeter, Silver (Coulombmeter), Milvay.** Same size and construction as No. 1043E, with detachable silver plates.....\$7.00

**1046E. Voltmeter, Copper (Coulombmeter), Pratt Rutger's Form.** Designed by Prof. Frank R. Pratt, Rutger's College, where it has been in successful use for a number of years. The electrodes are detachable spirals of heavy copper wire. On a spiral the deposit distributes itself uniformly. On a square plate it accumulates so heavily on the edges that it often crumbles away and introduces serious errors in the results. Consequently far more accurate and more uniform results are obtainable with this spiral form. Complete with glass jar,.....\$5.00

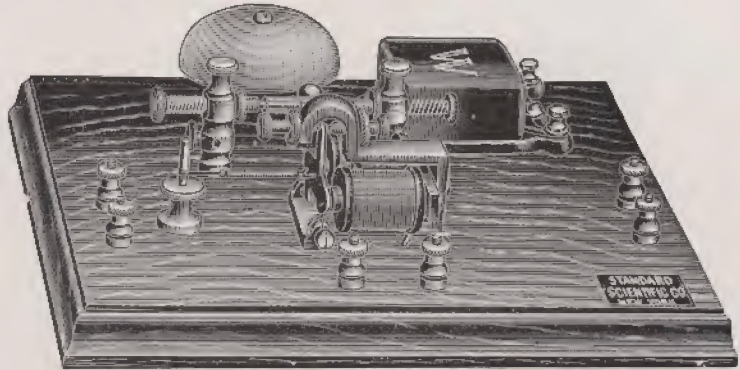
**1050E. Voltmeter-Ammeter Resistance Test Board, Dull's.** For convenience in connecting unknown resistance coils, voltmeter, ammeter, and resistance box, battery or other current source, into the circuit employed in the study of the laws of resistance as outlined in Exp. 60, "Laboratory Exercises in Physics," by Chas. E. Dull (1929). Size, 30x25 cm. As illustrated .....\$2.50



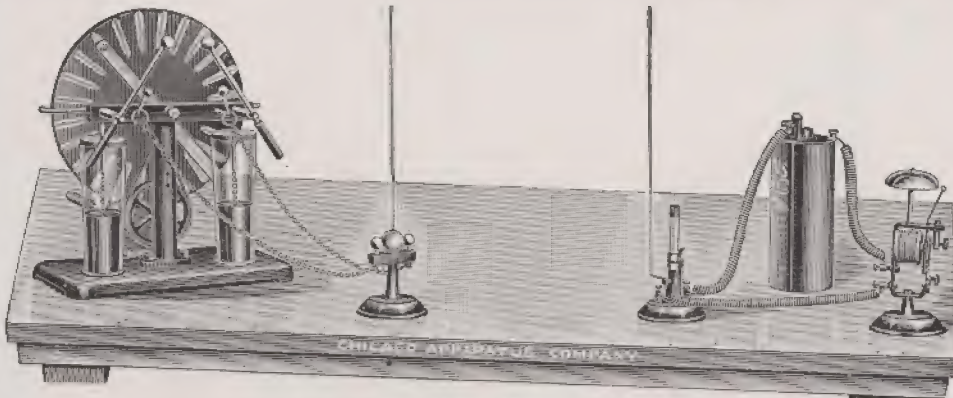
## Wireless Telegraph Apparatus



No. 1085E.



No. 1086E.



No. 1093E.

The apparatus listed below is the simplest for demonstrating in the lecture room the transmission and reception of wireless waves. It is also important from a historical standpoint, as the type of coherer used in our receiving station is of the Lodge type, which, like the Branly, was one of the first successful detecting devices employed in the reception of wireless messages.

A complete wireless set can be readily hooked up by the use of our No. 1085E Wireless Oscillator and No. 1086E Wireless Receiving Set, with the addition of such standard laboratory items as: induction coil,  $\frac{1}{4}$  inch spark, like our No. 643E; contact key, like our No. 658E; and four dry cells, like our No. 113E. If in addition, a sounder, like our No. 968E, is connected into the receiving circuit, the signals may be transmitted in code.

As complete directions and wiring diagrams are furnished with the instruments listed below, a complete set as described above can be readily and quickly assembled. Such a set when used with a  $\frac{1}{4}$  inch spark induction coil will give good results across any lecture room or laboratory. When larger coils are employed and the aluminum plates replaced by aerial and ground wires, transmission over greater distances is possible.

**1085E. Wire Oscillator.** For use with an induction coil as a transmitting station for wireless telegraphy. The spark gap is adjustable and provided with two pairs of binding posts, one pair for connecting into

the secondary circuit of an induction coil, the other for attaching the aluminum receiving plates. Complete on 10x15 cm. hardwood base, with two aluminum plates .....\$6.00

**1086E. Wireless Receiving Station.** Consists of a standard Lodge coherer; a bell, which acts both as a sounder and decoherer; and a sensitive relay, mounted on a 22.5x22.5 cm. neatly finished hardwood base. The wiring scheme is clearly marked on the upper surface of the instrument (not shown in cut) so that all circuits can be traced with ease. Complete with two aluminum receiving plates, complete with directions, and wiring diagram.....\$16.00

**1093E. Wireless Set, Simple.** For clearly illustrating the principles of wireless telegraphy. Its extreme simplicity and open construction enables the tracing of circuits and examination of every part. Very easy to operate and gives positive results. The vertical construction makes it an ideal set for the lecture table. One dry cell operates the receiving instruments; any Wimshurst machine, Toepler Holtz machine or induction coil, the sending instrument. Consists of a three-ball double spark gap with aerial wire, coherer with aerial wire, and a special electric bell; all mounted vertically on iron bases. Complete with full directions describing ten interesting experiments which can be performed with this outfit, but without dry cell and electric machine.....\$16.50

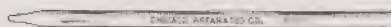




Nos. 145F-146F.



No. 170F.



No. 175F.



No. 155F.



No. 160F.



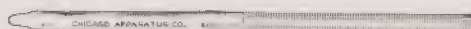
No. 165F.



No. 190F.



No. 195F.



No. 180F.



No. 185F.



No. 197F.

**145F. Fluoroscope.** For observing the bones in the hand, coins in a purse, etc., under the penetrating effects of X-rays. With removable calcium tungstate screen, 12.5x17.5 cm. (5x7 inches).....\$13.50

**146F. Fluoroscope, Professional Type.** The brilliant results obtained in X-ray examinations with this fluoroscope are due to the remarkable characteristics of its screen: 1. The fluorescent salt from which the screen is made is an absolutely stable chemical combination and is not affected by heat or dampness, by the continual bombardment by X-rays, or by pressure. It does not deteriorate with age, like the barium platinum-cyanide screens so quickly do. 2. The light emitted by this screen is brilliantly white. The images therefore present black and white contrasts which are pleasing to the eye. 3. The screen is free from visible grain. This is a most important attribute as it assures images with sharp clean-cut outlines. 4. It has absolutely no phosphorescent afterglow or lag. This quality prevents blurred outlines when examining moving objects.

Expert Roentgenologists use this type regularly for the fluoroscopic examination of fractured bones, etc. Used with our No. 656E Induction Coil and No. 545F X-Ray Tube, because of the penetrating x-rays produced by this equipment, this fluoroscope reveals the bony structure of the Hand, Wrist, Elbow, Foot, Ankle, Knee, etc., with a contrast, sharpness, and clearness impossible with calcium tungstate or barium-platinum-cyanide-screen-equipped fluoroscopes. The screen, 5x7 inches, is covered by a glass plate on the inside to protect it from dust and is readily removable for examination or replacement. It is mounted in a finely finished box with handle and furlined eyepiece .....\$26.50

**150F. Friction Can, Flannel.** With silk thread attached, for use with No. 170F Ebonite Rod, to illustrate that friction develops opposite charges in equal amounts .....\$0.25

**155F. Friction Pad, Cat's Fur.** Half skin for exciting friction rods, electrophorous, etc. ....\$1.00

**160F. Friction Pad, Flannel.** For exciting friction rods, etc. Size about 20x25 cm.....\$0.35

**165F. Friction Pad, Silk.** For exciting friction rods, etc. Size about 20x25 cm.....\$0.50

**170F. Friction Rod, Ebonite.** When rubbed with cat's fur becomes negatively electrified. Made of best quality hard rubber. Length, 25 cm.; diameter, 13 mm. ....\$0.35

**175F. Friction Rod, Glass.** Solid rod, better than a hollowglass tube. When rubbed with silk becomes positively electrified. Length, 25 cm.; diameter, 10 mm. ....\$0.30

**180F. Friction Rod, Glass.** Solid rod, one end ground, the other polished. One end becomes positively electrified and the other negatively when rubbed. Length 30 cm.; diameter, 13 mm.....\$0.60

**185F. Friction Rod, Wax.** When rubbed with flannel becomes negatively electrified. Size, 25 cm. x 15 x 15 mm. ....\$0.20

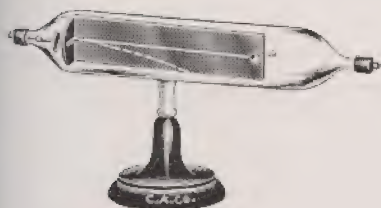
**190F. Friction Rod Support.** Better and more convenient than the suspended stirrup. The carrier, made of light-weight metal, is balanced on a hardened steel pivot mounted in the end of a hard rubber insulating rod. A bar magnet or friction rod resting on this carrier reacts readily to other magnetic or static charges. Without bar magnet.....\$2.50

**195F. Friction Strips.** Glass. One plain, the other with half of one face covered with silk. For illustrating that friction develops opposite charges in equal amounts. Size, 7.5x2.5 cm.....\$0.40

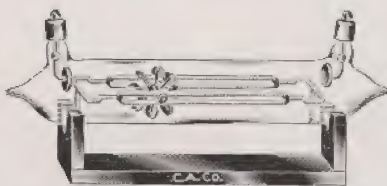
**197F. Gassiot's Cascade.** For producing an electrical cascade in a partial vacuum. In use this goblet, lined inside with the foil, is placed on the plate of an air pump and directly under the metal rod of a bell jar like our No. 70R, plate and rod being connected to the spark terminals of a static machine or induction coil. At reduced pressures the pink and violet colored discharges flow out of the goblet in water-fall or cascade fashion, producing a most beautiful effect .....\$1.50



## Geissler and Vacuum Tubes



No. 20F.



No. 22F.



No. 23F.



No. 25F.



No. 30F.

**20F. Crooke's Deflection Effect Tube.** For showing that cathode rays are deflected by a magnet. In this tube the cathode stream, narrowed down by a slit in a mica plate mounted directly in front of the cathode electrode, is caused to traverse the length of a mineral coated plate upon which it traces a fluorescent streak. The luminous band, which normally is quite straight, instantly bends into a circular arc, when the tube is approached by the end of a bar magnet. The curvature is either up or down according to which end of the pole is near the tube. Tube length, about 30 cm. With wooden stand.....\$7.50

**22F. Crooke's Mechanical Effect or Rolling Wheel Tube.** For showing that cathode rays can produce mechanical effects. The aluminum disk electrodes are placed near the top of the tube. Between them is a small mica-vane wheel mounted on glass rails. When the tube is excited by a coil of 2 inch spark, or larger, the wheel rotates rapidly, the upper vanes moving away from the cathode and the whole wheel rolling along the glass rails towards the anode. Obviously if the current is reversed, the wheel will spin and travel in the opposite direction. If the cathode stream is deflected by means of a magnet, the speed of the wheel will be altered. Length of tube, about 31 cm.; diameter, 5 cm. Complete with wooden stand .....\$12.00

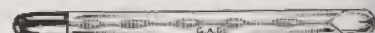
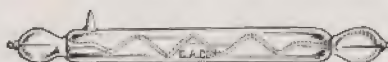
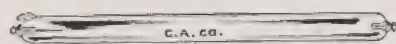
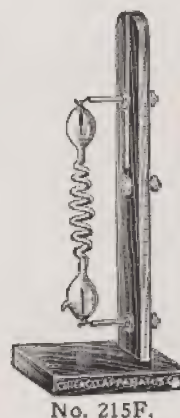
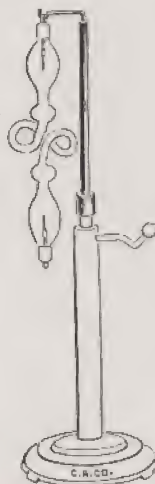
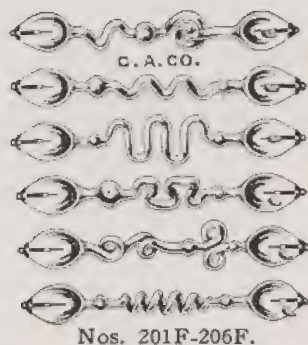
**23F. Crookes' Tube, Phosphorescent.** A vacuum tube containing several minerals which glow with brilliant colors while a discharge from a static machine or coil is passing through the tube. Being phosphorescent, the glow persists for a time after the discharge has ceased. Diameter of bulb, 9 cm.; length 14 cm. On polished wooden base.....\$5.00

**25F. Crookes Tube, Shadow Effect.** For showing that cathode rays travel in straight lines as is evidenced by the manner in which they cast a shadow, that they are deflected by a magnetic field, and that fluorescent glass fatigues under their stimulus. The metal cross is hinged so that it may be caused, by tipping the tube, to lie down or stand erect at will. When the cross is down, the whole large end of the tube will glow with a greenish-yellow fluorescence. When erect, a sharp shadow will appear in this fluorescent area. Approaching the tube with a magnet causes the fluorescent area to shift, obliterating the shadow partially or entirely, showing that the rays are being deflected. If the shadow of the cross is thrown on the walls of the tube for some time and the cross then shaken down, the pattern of the cross now will glow brighter than the surrounding portion, revealing that the portion originally screened from the cathode rays now responds more vigorously than the portion that underwent prolonged exposure to them. Length, about 28 cm.; diameter of large end, 8 cm. On wooden stand.....\$6.00

**30F. Crookes' Heating Effect Tube.** For showing that cathode rays heat bodies upon which they fall. In this tube the cathode electrode is a section of a hollow square. In the center is mounted a square of platinum foil. In action the rays come off at right angles to the cathode forming a cone with its apex in the plane of the platinum. Thus the energy of the rays, concentrated into a small space, is so great that the foil at the tip of the cone becomes white hot. By deflecting the cathode stream with a magnet the position of the heated spot can be shifted. Diameter of bulb, 12 cm. On wooden stand.....\$7.50



## Geissler and Vacuum Tubes—Cont.



## Geissler Tubes

Sealed glass tubes of various designs, and of various kinds of glass, containing some highly rarefied gas and provided at each end with an improved electrode for easy connection to a static machine or coil. Any static machine or induction coil will operate these tubes. When an electric discharge is passed through them the gas becomes luminous, while the different kinds of glass exhibit fluorescence as follows: Uranium-Yellow; Iron-Green; Lead-Blue.

- 200F. Geissler Tube. 15 cm. long.....\$0.75  
 201F. Geissler Tubes. 15 cm. long, set of six, assorted, in box .....\$4.25  
 205F. Geissler Tube. 20 cm. long .....\$0.90  
 206F. Geissler Tubes. 20 cm. long, set of six, assorted in box.....\$5.00  
 210F. Geissler Tube Holder. A metal rod with socket at its lower end to fit No. 515F Support and hook at top for suspending Geissler Tubes or No. 270F Lightning Plate. Nickel-plated.....\$0.65  
 215F. Geissler Tube Support. Consists of a 12.5x12.5 cm. wood base with a 30 cm. wood upright, provided with binding posts and adjustable hooks for supporting any tube from 15 to 25 cm. long. This stand is entirely finished in dead black against which the illuminated Geissler tube stands out in bold relief. Ideal for the lecture table use. Without Geissler Tube .....\$3.00

- 211F. Aurora Tube. A simple vacuum tube, 25 cm. long, with an electrode in each end. A discharge through this tube produces a beautiful colored auroral glow .....\$2.00  
 3600F. Aurora Tube. Same as No. 211F, but provided with open side tube for exhausting. Length, 25 cm. ....\$1.75  
 212F. Holtz Tube. Consists of a vacuum tube, 15 cm. long, with a series of partitions provided with small tapered openings to show that the discharge will pass in but one direction through such openings.....\$2.50  
 213F. Fluorescent Tube. This is a double tube, 20 cm. long, the inner one of uranium glass, the outer being filled with some fluorescent liquid such as eosine, quinine, kerosene, aesculine, or uranine. When a spark is passed through this tube the liquid gives off light of a color differing from its own (fluorescence) .....\$1.50  
 214F. Phosphorescent Tube. This is a double tube, 20 cm. long, the outer of which contains crystals of calcium sulphide and zinc sulphide. When a discharge passes through the tube the crystals phosphoresce beautiful green and violet colors, showing how radiant matter may produce visible light. ....\$2.00  
 216F. Phosphorescent Mercury Tube. A double vacuum tube, 20 cm. long. The inner tube consists of a series of bulbs while the outer contains a quantity of mercury. When shaken, friction resulting from mercury falling on the glass bulbs, produces a beautiful phosphorescent glow. As no static machine or coil is required, this tube is not provided with terminals .....\$2.50



## Geissler and Vacuum Tubes—Cont.



No. 217F.



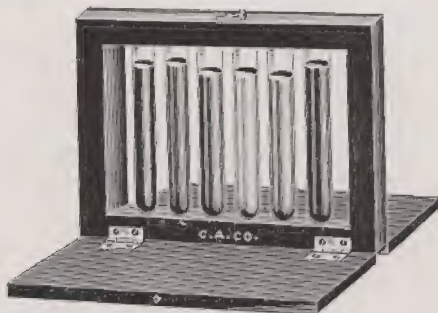
No. 218F.



No. 219F.



Nos. 326F-346F.



No. 3603F.



No. 3605F.

**217F. Geissler Tube, Demonstration Form.** Total height, 28 cm. Fancy uranium glass spiral in bulb. On weighted wood base.....\$4.00

**218F. Low Vacuum Tube.** Spherical shape with four electrodes. A discharge through this tube traces a path of colored light from the cathode to whichever of the other three terminals is made the anode. On wood base .....\$7.50

**219F. High Vacuum Tube.** Spherical shape with three electrodes. A discharge through this tube shows no visible path between cathode and anode. Fluorescence of the walls of the tube directly opposite the cathode electrode proves that the cathode rays travel across the tube in straight lines....\$7.50

## Spectrum Tubes

These tubes, also known as Plücker Tubes, are ready prepared for use in spectrum analysis and lecture work. They consist of two glass tubes about 7.5 cm. long by 13 mm. diameter joined by a glass capillary about 10 cm. long by 7 mm. diameter. The ends are provided with heavy rod electrodes terminating in a cap and ring on the outside, the latter for convenience in connecting them into circuit. During evacuation a trace of pure gas is introduced into the tube which is then sealed-off at reduced pressure. Operated with a static machine or a small induction coil (like our No. 650E) a bright discharge passes through the tube, varying in color and spectrum with the contained gas. The discharge is especially brilliant in the capillary section where the current density is greatest. In a spectroscope this highly luminous section produces an intensely brilliant spectrum containing the lines characteristic of the gas in the tube. Hence these tubes are especially valuable for use with a grating spectro-scope in wave-length determinations, for spectrum

analysis by the comparison method, and for acquainting students with the spectra of the better-known gases in their pure form. Overall length, 25 cm.

326F. Spectrum Tube, Argon Gas.....	\$5.00
328F. Spectrum Tube, Bromine Vapor.....	2.00
330F. Spectrum Tube, Carbonic Acid Gas.....	2.00
331F. Spectrum Tube, Chlorine Gas.....	2.00
332F. Spectrum Tube, Helium Gas.....	5.00
335F. Spectrum Tube, Hydrogen Gas.....	2.00
336F. Spectrum Tube, Iodine Vapor.....	2.00
337F. Spectrum Tube, Mercury Vapor.....	2.00
338F. Spectrum Tube, Neon Gas.....	5.00
340F. Spectrum Tube, Nitrogen Gas.....	2.00
345F. Spectrum Tube, Oxygen Gas.....	2.00
346F. Spectrum Tube, Water Vapor.....	2.00

**3603F. Fluorescent Liquids.** For showing the character of fluorescence exhibited by certain liquids when exposed to sunlight, arc-light, colored light, ultra violet light, etc. Consists of six fluorescent liquids in sealed glass tubes, mounted in a wooden exhibition rack with back and cover, forming a case measuring 21x17 cm. when closed. Each tube is plainly marked with the liquid it contains....\$10.00

**3605F. Phosphorescent Sulphides of Alkaline Earths.** For revealing the characteristic phosphorescence of alkaline earth sulphides after exposure to X-rays, radium radiations or ultra violet light. Each sulphide is contained in a flattened glass tube, 11 cm. long, and the five different varieties are assembled in a velvet lined case with hinged lid. Each tube is plainly marked with the name of its content.....\$10.00



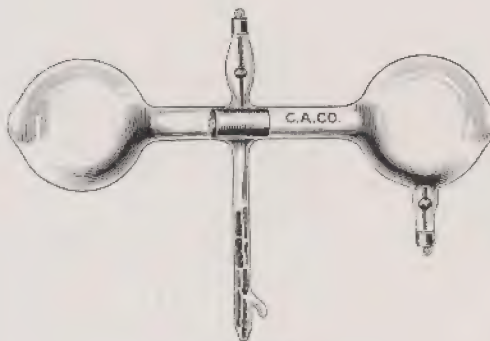
## Vacuum Tubes—Cont.



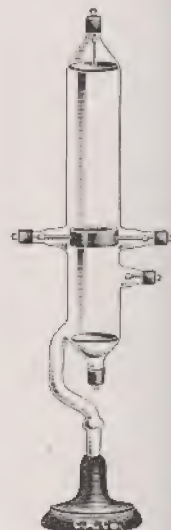
No. 3610F.



No. 3615F.



No. 3620F.



No. 3625F.

**3610F. DeLaRives Apparatus.** When a current flows perpendicular to the direction of the lines of force in a magnetic field, rotation will result if the medium through which the current is flowing is free to move. This is due to the force exerted on the current by magnetic field. That the reaction on a discharge through a gas at reduced pressure is the same, is beautifully illustrated by this tube. The lower electrode is in the form of a ring. A sealed-in glass tube permits the extended core of the electromagnet to extend through and beyond this ring. In action, a reddish colored concentrated discharge passes between the electrodes, which when the electromagnet is energized, will rotate about the core. Reversing the polarity of the electromagnet reverses the direction of rotation. From the polarity of the core and the direction of rotation, the direction of the current in the discharge can be deduced. Diameter of bulb, 9 cm.; overall height, 32 cm. Complete with electromagnet .....\$12.50

**3615F. Canal Ray Tube, Goldstein's.** For demonstrating that positive and negative ions appear in a discharge tube; and that the positive form the canal rays observed by Goldstein in 1886, while the negative form the cathode rays. Cathode ray emission is due to a positive ion bombardment on the cathode. The slots in the cathode of this tube permit some of the positive ions to pass into the upper portion of the tube, forming the so-called canal rays. In the field of a powerful electromagnet the canal rays deflect slightly. From the direction of the deflection and of the lines of force, it can be shown that they carry positive charges. The cathode rays in the lower section will under the influence of the same magnetic field, show a much larger deflection in the same direction, indicating that they are negatively charged. Diameter of tube, 4 cm. Overall height, 40 cm. On polished wooden base.....\$11.00

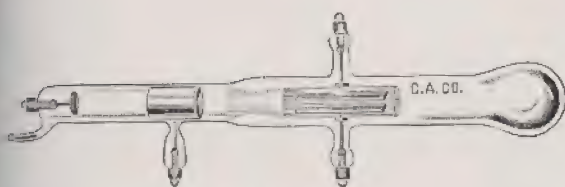
**3620F. Canal Ray Tube.** For the qualitative study of canal rays (positive rays) and cathode rays (negative rays) as outlined on page 463, "Physics" by Duff, Lewis, Mendenhall, Carman and Knipp. The

cathode is a hollow cylinder with a small central aperture in each end, providing a small circular, horizontal path for the rays. The anode is in the tube extending downwards from the bulb at the right. For the further reduction of the vacuum, by immersion in liquid air, the central lower bulb is filled with charcoal. In action, the cathode ray beam emerges from the face of the cathode and reaches the opposite side of the right hand bulb, where it produces noticeable heating of the glass. Due to the presence of a trace of helium, introduced at low pressure before the tube is sealed-off, the cathode stream presents a greenish-blue color. The positive ions form at the edge of the Crookes' dark space, fall towards the cathode, and a portion passes through the perforated cylinder, forming a stream of positive rays which falls upon the glass at the end of the left-hand bulb, warming it gently. The helium gas gives these rays a distinct reddish color. Placing the poles of a horseshoe magnet astride the horizontal connecting tube to the right of the cylindrical electrode will cause the cathode rays to be completely deflected out of their course. Similarly, if the magnet is placed to the left of the cylindrical electrodes, no appreciable deflection of the positive rays will take place. Bulbs, 10 cm. diameter; overall width, from extremity of one bulb to extremity of the other, about 37 cm. ....\$30.00

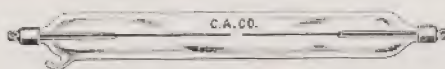
**3625F. Canal Ray Tube, Wien's.** For showing the positive and negative charges of cathode and canal rays. In use the perforated plate at the center is earthed, the wire electrode directly below it made the anode, and the disc at the top the cathode. An electroscope is connected to the lower disc electrode. The cathode rays passing through the perforated plate strike the lower disc and the electroscope indicates the flow of negative electricity. If the perforated plate remains earthed and is made the cathode, instead of the top disc, the electroscope now will show the flow of positive electricity. Diameter of tube, 4.5 cm.; overall height, 45 cm. On polished wooden base .....\$13.50



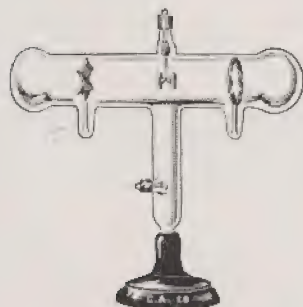
## Vacuum Tubes—Cont.



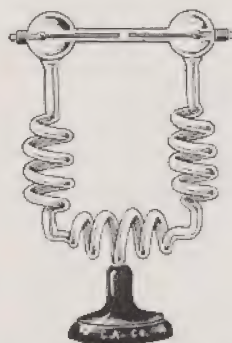
No. 3627F.



No. 3630F.



No. 3635F.



No. 3640F.

**3627F. Vacuum Tube, Thomson's.** For determining the velocity and ratio of charge to mass of the electron in cathode rays by the crossed field method. The construction of this highly exhausted tube is such that when excited by a coil or static machine the cathode rays starting from the end electrode pass through a small hole in the metal plug in the narrow neck, thence in a straight line between the two plate electrodes to the far end of the tube. Here the pencil of rays produce a bright fluorescent spot. On introducing an electric field, by connecting a battery to the plate electrodes, the bright spot is deflected vertically. By measuring this deflection  $e/mv^2$  can be determined,  $e$  being the charge on the electron,  $m$  its mass,  $v$  its velocity. If the rays are now also exposed to a magnetic field with the lines of force vertical, the spot will describe a circle. By measuring the radius of this circle the value of  $e/mv$  can be found. From the two observations the value of both  $e/m$  and  $v$  can be calculated. Length, about 50 cm. ....\$27.50

**3630F. Glow Light Oscillograph Tube, Gehrcke Ruhmer.** For the visual study, by the rotating mirror method, of the curve shape of the current alterations in A.C. circuit, condenser discharges, induction coil discharges, etc. Also provides a simple means for determining the frequency of A.C. circuits by noting the mirror speed, when the latter is adjusted to the point of synchronism. Consists of an evacuated tube, 30 cm. long by 3 cm. diameter, with two axially arranged heavy wire electrodes with a very small gap between them at the center. In action both electrodes appear to be covered with a bluish glow, but actually the glow is only upon the electrode which at the moment happens to be the cathode. This glow is proportional to the momentary current and the curve shape is rendered visible

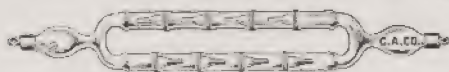
by a rotating mirror. The voltage—110 and 220 volts—of lighting circuits is too low to operate this tube, which responds only to voltages of several thousand or more. To overcome this, the lighting circuit, the frequency of which is to be measured, should be connected to the primary and the tube to the secondary terminals of a transformer like our No. 1041E. Our No. 892R Rotator with Speed Indicator and No. 954R Cubic Mirror will give excellent results in connection with this tube. ....\$6.00

**3635F. Puluj's Double Shadow Tube.** Similar to No. 25F, but with two crosses, one solid, the other cut-out. The cathode electrode, at the center, is of the double-disc type. When this tube is excited with a coil or static machine the shadow of both crosses appear simultaneously at the enlarged ends. The shadow of the solid cross appears as a dark pattern surrounded by fluorescent glass, while the other appears as a fluorescent pattern with a dark shadow around it, making a very striking demonstration. Length, about 28 cm.; overall height, 25 cm. On wooden stand ....\$10.00

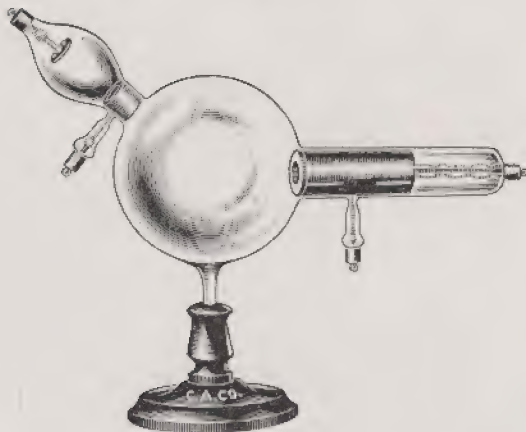
**3640F. Hittorf's Tube.** For showing that resistance and not distance determines the path of a discharge through a vacuum tube. In this tube, of rectangular shape, two paths between the electrodes are provided; one very short, the other very long. The vacuum is so adjusted that the short path lies wholly within the Crookes' dark space, the resistance of which is extremely high because of the absence of gaseous ions in this space. Hence, when the tube is excited with a coil or static machine, the discharge takes the long path through spirals—the path of least resistance—instead of the extremely short path directly between the electrodes. Height 26 cm. On wooden stand ....\$9.00



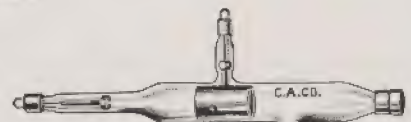
## Vacuum Tubes—Cont.



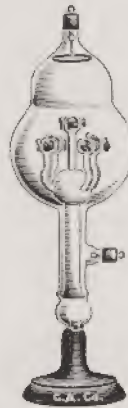
No. 3645F.



No. 3655F.



No. 3650F.



No. 3660F.



No. 3665F.



No. 3670F.

**3645F. Holtz's Tube, Double.** In this tube, the tapered openings in the partitions of one arm point in one direction, and in the other arm in the opposite direction. When a high potential alternating current is impressed on the terminals, the discharge passes through one arm only. This is indicated by the bright glow in one arm and the absence of glow in the other. Reversing the discharge causes the flow to take place in the other arm. The discharge of a coil with a current breaker in the primary, will because of the wide differences of potential at make and break, cause both arms to glow. However, the glow in one arm is far more intense than in the other. Because of the manner in which this tube functions it is useful for revealing the extent to which the discharges in opposite directions in high frequency currents approach equality. For the same reason the tube is also useful for suppressing the low voltage make potential of an induction coil discharge. When used for this purpose in series with another vacuum tube, the latter is under the excitation of the high voltage break potential only. Thus, the second tube, operating at maximum efficiency, yields the most brilliant results which it is capable of producing .....\$5.00

**3650F. Lenard's Tube.** For showing that cathode rays can be passed from the inside of a discharge tube, through thin aluminum foil, to the air outside. The cathode is an aluminum disc fastened to a stiff wire surrounded by a glass tube, which in turn is surrounded by a metal strip comprising the anode. The end of the tube is closed by a stout metal cap in the middle of which is a small hole covered with very thin aluminum foil which can be readily renewed when necessary. In use the terminals are connected to an induction coil, the cap and anode grounded, and the tube evacuated with a high vacuum pump until a diffuse light, visible in a dark room, spreads from the aluminum foil window into the outside air for a distance of several centimeters.

From the window also proceed the so-called Lenard rays, which like cathode rays can produce fluorescent effects on zinc sulphide, X-ray screens, etc. They will affect photographic plates, ionize gases, and change the color of haloid salts of the alkali metals. They can also be deflected by a magnet. Length, about 35 cm.

Without stand .....\$12.50

**3655F. Vacuum Tube, Perrin's.** For showing that cathode rays carry negatively charged particles. The flat electrode at the left extremity is the cathode. The perforated metal plug electrode directly in front of the cathode is the anode. In action a narrow beam of cathode rays is projected against the walls of the glass bulb, directly opposite the perforated anode and just below the two coaxial metal cylinders in the tube at the right, where it produces a bright fluorescent spot. If the outer of the coaxial hollow cylinders is grounded, the inner connected with an electroscope, and the cathode ray deflected vertically by a magnet, so that the bright spot disappears in the inner hollow cylinder, the electroscope will indicate that it has received a negative charge. Diameter of bulb, 15 cm. On finely finished wooden stand .....\$20.00

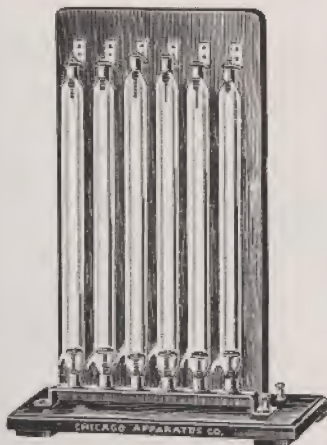
**3660F. Vacuum Tube, with Fluorescent Minerals.** Within the bulb are mounted five different minerals, each securely held in strong glass prongs. Directly above them is a disc cathode electrode. In action a stream of cathode rays impinges upon the minerals, causing each to fluoresce with its characteristic color and brilliancy. Overall height, 36 cm. On finely finished wooden stand.....\$10.00

**3665F. Vacuum Tube, with Two Roses.** This tube contains fluorescent minerals arranged and mounted to represent two roses. Directly above them is a disc cathode electrode. Under the action of cathode rays these flowers become luminous, glowing in the beautiful fluorescent colors characteristic of the minerals from which they are made. In the dark the effect is greatly enhanced. Overall height, 27 cm. On polished wooden stand.....\$4.00

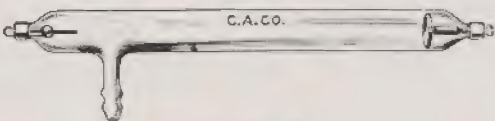
**3670F. Vacuum Tube, with Bouquet of Flowers.** Under the stimulus of cathode rays certain minerals exhibit more pleasing and more colorful effects than others. In this tube the choicest minerals are artistically arranged to resemble a bouquet of flowers. Directly above is a disc cathode electrode. When the tube is excited by a static machine or coil, the bouquet glows brilliantly, each mineral contributing its own characteristic color and intensity. In the dark the beauty of the effect is greatly enhanced. Overall height, 36 cm. On polished wooden stand....\$12.00



Vacuum Tubes—Cont.



No. 3675F.



No. 3682F.



No. 3680F.

**3675F. Vacuum Scale.** Six vacuum tubes for revealing the character and appearance of electrical discharges through gases at reduced pressures. The tubes are mounted on a wooden frame provided with terminals for connection to the high potential current source. A movable contact lever at the back directs the discharge through the desired tube. The manner of mounting makes demonstrations easy and effective. The degree to which each tube is evacuated and the effects it produces in action are as follows: No. 1. 40 mm. vacuum. Numerous violet streamers pass between the electrodes and there is a distinct, though small glow at the cathode. No. 2. 10 mm. vacuum. The discharge through the tube has become concentrated in a single vivid red colored, luminous streamer along the axis of the tube. No. 3. 6 mm. vacuum. The luminous band has expanded and fills the tube except for a dark space near the cathode. No. 4. 3 mm. vacuum. Shows shifting layers or striae. The dark space has increased in length and become divided into two parts separated by a luminous partition. No. 5. 0.14 mm. vacuum. The tube is well filled with brilliant light and the glass upon which the cathode rays impinge exhibits a greenish-yellow fluorescence. No. 6. 0.03 mm. vacuum. The tube is filled with a pale blue light and the glass exhibits a strong fluorescence, greenish in color, characteristic of the X-rays which are produced at this low pressure. Complete, as illustrated, with six-point lever switch on the back of the frame for quickly introducing the desired tube into circuit, without changing the lead wires. **\$20.00**

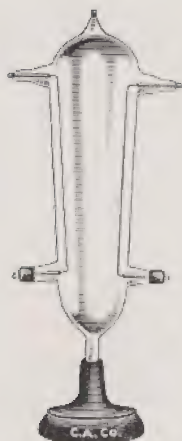
**3680F. Vacuum Discharge Tube, Lecture Demonstration Type.** For demonstrating the phenomena attending the discharge between electrodes under reduced pressures. The tube is approximately 80 cm. long x 5 cm. inside diameter and is provided at either end with large flat aluminum electrodes. A side branch is provided for clamping the tube to a stand

and for making connection, by means of rubber tubing, to the vacuum pump. In use an induction coil furnishing a discharge of about 3/4-inch spark length, like our No. 650E, is connected across the electrodes. At atmospheric pressure no discharge passes between the electrodes; at 100-150 mm. of mercury bluish threads of light trickle along the walls of the tube; at 30-40 mm. the threads of light thicken and travel for the most part through the gas; at 0.1 mm. the cathode glow and Crookes and Faraday dark spaces have put in their appearance; at 0.04 mm. the Crookes and Faraday dark spaces widen; at 0.001 mm. the Crookes dark space is well developed and the glass exhibits brilliant fluorescence. At still lower pressures the vacuum becomes "hard," the diminishing brilliancy indicating the flow of less and less current. (See page 453, "Physics," by Duff, Lewis, Mendenhall, Carman and Knipp) **\$15.00**

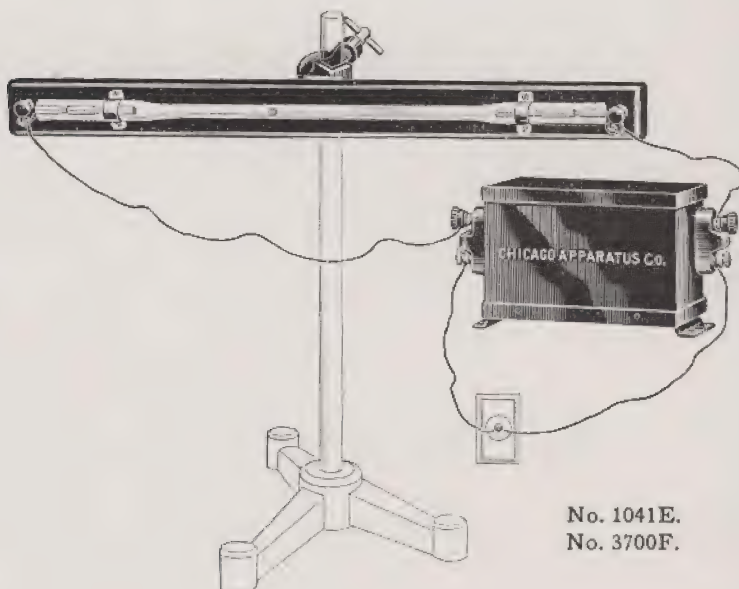
**3682F. Vacuum Tube with Concave Electrode.** For demonstrating in a more striking manner the phenomena associated with the discharge of electricity through gases at reduced pressure. The cathode, of aluminum, is concave and has a radius of curvature of about 5 cm. The anode is a cylindrical aluminum rod. The tube measures 44 cm. long by 3.5 cm. in diameter and is provided with an open side tube for connection, by means of a rubber tube, to a vacuum pump. With the terminals connected to an induction or static machine, and the pressure within the tube reduced to .02 mm. of mercury many interesting effects are exhibited, such as: Crookes' dark space, Faraday's dark space, Negative glow, Positive column, X-Ray fluorescence; where the cathode rays impinge on the walls of the tube. Path of cathode rays to a focal point at the center of curvature of the cathode electrode. By deflecting the cathode rays with a magnetic field other striking effects are produced **\$10.00**



## Vacuum Tubes—Cont.



No. 3685F.

No. 1041E.  
No. 3700F.**3685F. Greinacher's Series-Ladder Discharge Tube.**

For showing that the discharges of induction coils and static machines are not continuous, but consist of a series of separate sparks. This tube is pear shaped, partially exhausted, and provided with two wire electrodes arranged so as to form a gap of gradually increasing size. When a discharge passes through this tube, the first spark naturally jumps across the shortest distance between the electrodes—at the bottom. The passage of the spark ionizes and heats the gas along its path, the heating causing the ionized gas to rise. The next spark, instead of jumping across the shortest gap, will pass through the longer displaced path of ionized air because of the lower resistance of the latter. In like manner each succeeding spark will traverse a longer and higher path between the electrodes, until the top is reached, when the whole performance starts anew from the bottom again.

Viewed from a short distance, the action of this tube is that of a spark "climbing" up an invisible ladder. The action is entirely automatic and striking and impressive in the extreme. By photographing the complete series of spark jumps—from across the smallest to the largest gap—the character of the individual sparks can be studied, and the difference between static machine and induction coil discharges revealed. Overall height, 35 cm. On wooden base .....\$13.50

**Neon Sign Demonstration Apparatus**

With the apparatus listed below, constructional details of Neon Illuminated Signs can be shown and the principles upon which they operate demonstrated.

The tube has an overall length of 50 cm. with a luminous section 30 cm. long by 13 mm. in diameter. Every detail of the large and elaborate electrodes are clearly revealed. The tube is mounted on a blackened wood back, 55x5 cm. against which the glow of the tube will stand out in bold contrast, even in a lighted room. On this back are also two insulating-head binding post terminals, and a clamp for attaching the whole to a support. The central section glows intensely with the color so characteristic of neon signs—red or blue—when excited by the secondary voltage of the transformer.

The transformer is designed to operate on 110 volt, 60 cycle, A.C. lighting circuits and delivers a secondary current of 5,000 volts and 25 milliamperes, which is correct for properly exciting this tube. This transformer is also suitable for exciting Geissler and other vacuum tubes; however, when used for this purpose, the primary current should be reduced by means of a rheostat or lamp bank, as the full output is apt to injure the lightweight electrodes of such tubes.

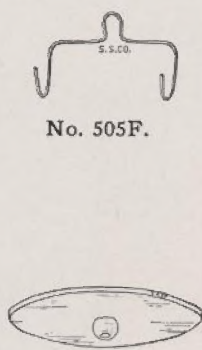
**3700F. Neon Sign Tube.** Length 50 cm., with luminous section 30 cm. x 13 mm. on blackened wood back with insulating-head binding posts and clamp for attaching to support.....\$6.00

**1041E. High Potential Transformer.** For operation on 110 volt, 60 cycle A.S. lighting circuit. Secondary output, 5,000 volts and 25 milliamperes.....\$12.50





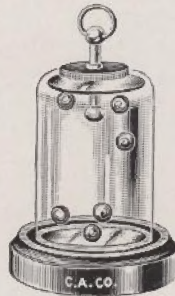
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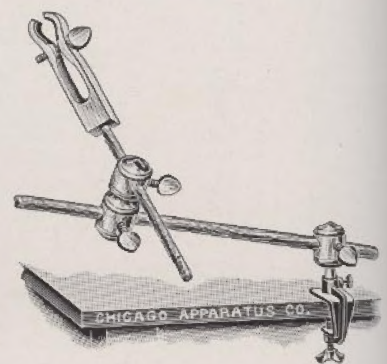
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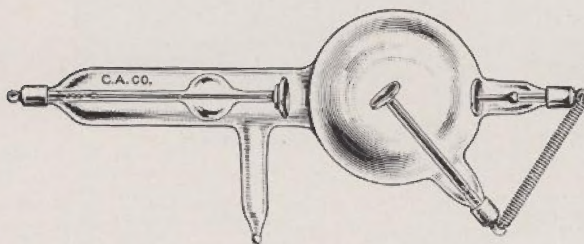
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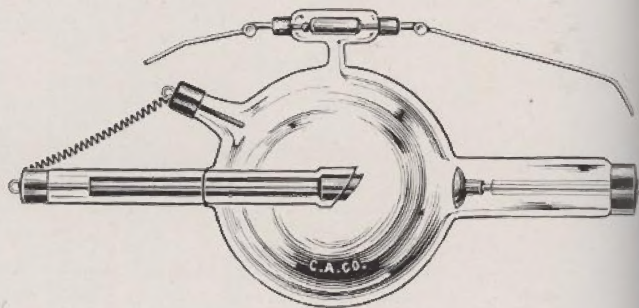
No. 520F.



No. 570F.



No. 541F.



No. 545F.

**69B. Stirrup Stand.** Japanned iron base, nickel-plated rod with hook; height, 37.5 cm. An excellent stand from which to suspend stirrups, pith balls, etc. **\$1.50**

**505F. Stirrup.** For suspending electrified friction rods, bar magnets, etc. Made of heavy brass wire, with silk suspension; length, 12.5 cm. **\$0.15**

**515F. Support, Universal.** For holding all electrostatic accessories provided with a socket in the base. Saves the cost of a support for each extra accessory. Consists of an ebonite insulating rod mounted on a japanned iron base. Height, about 20 cm. Provided with a metal top which fits into socket in base of accessories, and hook for attaching chain from static machine **\$1.00**

**516F. Support Top.** Metal disc, 15 cm. diameter designed to fit on top of No. 515F, making a convenient insulating stand **\$0.90**

**520F. Volta's Hail Storm.** Consists of a wood base with a metal disc on its bottom, a 6x8.5 cm. glass shade with a metal disc inside near the top, and a number of pith balls. Designed to fit No. 515F Support. When connected to a static machine in operation, the balls bound back and forth between the metal discs **\$2.50**

**541F. X-Ray Tube, for Static Machines or Induction Coils.** This tube is designed and constructed for use with static machines and induction coils producing a spark discharge 8 to 10 cm. long. It is especially suited to the needs of the average educational laboratory. It yields satisfactory results with No. 354F Toepler-Holtz Machine or No. 361F Wimshurst Machine, but the best results are obtainable with a No. 653E or No. 654E Induction Coil. The penetration of the X-rays produced by this tube are sufficient for viewing the bones of the hand and wrist,

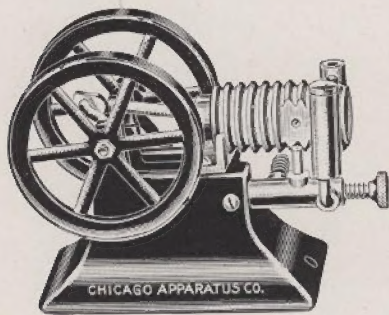
but not of thicker parts of the body. For observing the bony structure of the hands, coins in a purse, and other effects revealing the penetrating power of X-rays, requires the use of either No. 145F or No. 146F Fluoroscope. Diameter of tube, 8 cm. (3 1/4 inches) **\$12.00**

**545F. X-Ray Tube, Tungsten Target Type, 6-inch Diameter.** Especially pumped for use with our No. 654E or No. 656E X-Ray Coil. Remains cooler and maintains a more constant vacuum than tubes of smaller diameter. Also for these reasons it will not require vacuum reduction treatment as frequently as the smaller sizes. The chamber to which the long slender wire terminal is attached is filled with asbestos, treated with a chemical which vaporizes into a gas by the passage of a current. By adjusting the slender wire so that its terminal is within one inch of the cathode terminal and passing a spark for a second or two the internal resistance of the tube is lowered. This reducing treatment is only necessary when the vacuum in the tube becomes too high, as it will after considerable use. This heavy Tungsten target type tube is identically the same as that used in professional medical work where results and service are paramount to a small difference in cost. **\$38.50**

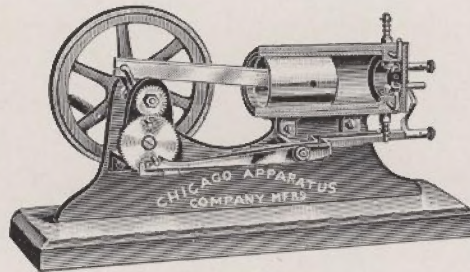
**570F. X-Ray Tube Support.** Forms a rigid support when clamped to the edge of a table. Cannot topple over like the old style stand with base. Provides a very wide range of adjustment and for this reason the tube can always be arranged in the most convenient position. The large jaws are properly shaped and felt lined, hence will hold the tube securely and without the slightest danger of injury.

Black-glass enameled iron clamp with wooden rods and clamp provided with means for adjusting to any conceivable position. **\$6.00**

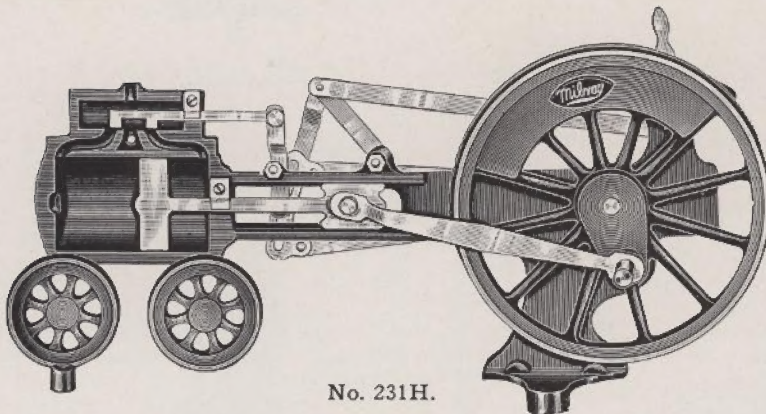




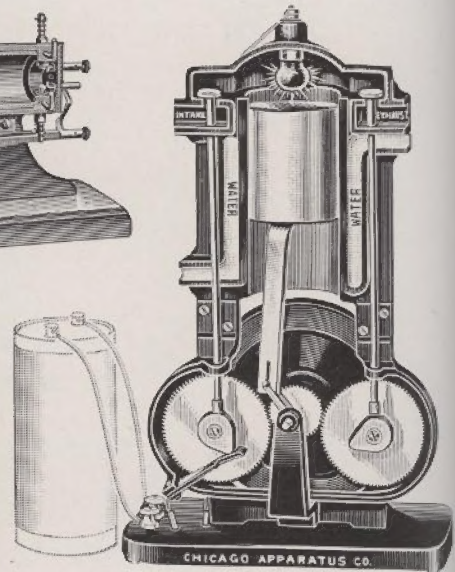
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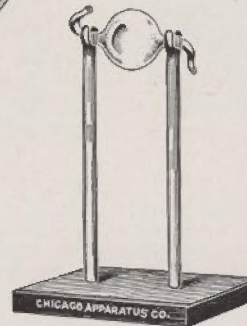
No. 221H.



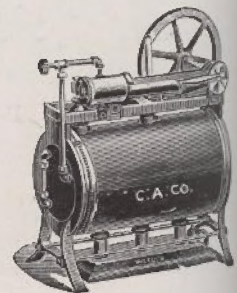
No. 231H.



No. 226H.



No. 228H.



No. 232H.

**218H. Engine, Gas, Working Model.** Operates only on gas manufactured from coal (artificial gas). Size of base, 8x15 cm. ....\$8.50

**221H. Engine Model, Gas.** A true reproduction, in section, of the modern gas engine. All parts—inlet valve, exhaust valve, piston, spark plug, connections, shafts, etc.—are adjusted to their proper position. Intake, compression, explosion and exhaust strokes are easily demonstrated. If the secondary of an induction coil is connected in series with the spark plug, the spark may be shown at the proper time. On hardwood base, 10x30 cm. ....\$14.50

**226H. Engine Model, Gas, Milvay.** Large size, 37.5 cm. high. Can be seen by every student in a large class. The spark plug is represented by a small incandescent bulb, colored red, which flashes at the beginning of each explosion stroke, thus producing a most realistic effect. One dry cell operates the lamp, thus doing away with the induction coil used in older models. The Milvay is a model of the vertical four-cycle type of gas engine—the type that is used in automobiles, motor trucks, aeroplanes, motor boats, motorcycles, etc. The four cycles—intake stroke, compression stroke, explosion stroke and exhaust stroke—are made perfectly clear with the Milvay. All parts are adjusted to their proper position and shown to the best advantage. It illustrates valve action, cam action and timing gear action. It also shows the following parts in their true relationship: Cylinder, piston rod, crank shaft, valves, valve stems, gas intake port, exhaust port, water jacket, valve lifting cams, crank case, spark plugs (incandescent lamp) and fly-wheel. It is much larger and superior to the horizontal gas engines on the market. The Milvay is used in such well known institutions as Tulane University, New Orleans, La.; Ohio Univer-

sity, Athens, Ohio; Lane Technical High School, Chicago, Ill., etc. Made entirely of metal, substantially constructed and handsomely finished. ....\$25.00

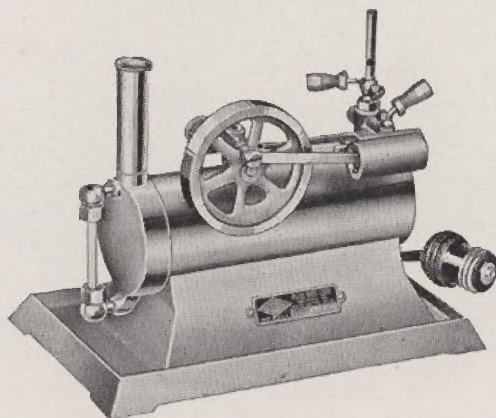
**228H. Engine, Hero's (Steam Reaction Wheel or Rotating Ball).** For exhibiting the reaction set up by steam escaping from lateral jets. The ball, 50 mm. in diameter, and made of Pyrex heat-resisting glass, will rotate rapidly in its mount when partially filled with water and heated in a Bunsen burner or alcohol lamp flame until steam issues from the jets. Mounted on 10x15 cm. hardwood base. Overall height, 28 cm. ....\$3.50

**231H. Engine Model, Steam, Milvay.** Large size, 18 cm. high, 38 cm. long. Made entirely of metal. Each part is accurately formed and adjusted. Complete model of locomotive engine, showing a section through the steam chest with piston and valve connected to their proper parts. Clearly illustrates link motion, use of reversing gear, and action of eccentric ....\$6.50

**232H. Engine, Steam, Working Model.** Horizontal type with boiler. Shows all essential parts and is well built. Overall height, 9¾ inches; overall length, 9½ inches; weight, about 5 lbs. Complete with 3-tube alcohol lamp. ....\$7.50



## New Engine Models—Electrically Heated



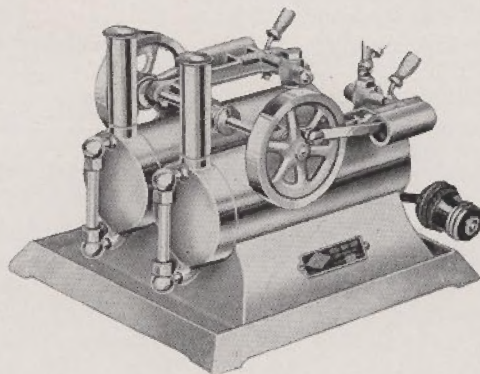
No. 234H.

These modern working models will appeal to teachers who appreciate devices that permit of more effective demonstrations, that are safer and more convenient to use, that are more efficient, that are more durable, that are finer in workmanship, and that are more pleasing in appearance; for such devices are always far more attention compelling. Then, too, these new electrically heated engines always stay bright and clean. There is no smudge formation and no fuel to spill as in the older crude, inefficient, flame-heated models. They operate direct from any 110-volt A.C. or D.C. standard light socket. The series includes a single cylinder reciprocating type steam engine, a double cylinder reciprocating type steam engine, a turbine type steam engine, and a hot air engine described in detail below.

**234H. Steam Engine, Single Cylinder Type, Electrically Heated.** Seamless drawn copper boiler, heavy cast base, accurately machined brass running parts with steel connections. Base, steam chest, and fly-wheel spokes finished in bright red enamel; other parts, nickel plated. The gauge glass, held in threaded packing nuts, is readily replaceable in case of breakage. A safety blow-off valve permits steam to escape through stack when pressure becomes excessive. The well-balanced fly-wheel provides smooth, vibrationless action. A small pulley attached to the shaft enables the operation of small devices. A cord or rubber band may be used as a belt for transmitting the power. Operates for about 45 minutes on one filling. A hand-controlled whistle provides a simple means for testing the steam pressure and illustrating the principle of the steam whistle. A hand-controlled throttle regulates speed. Small current consumption, 300 watts. Size,  $9\frac{1}{4} \times 5\frac{3}{4} \times 7\frac{1}{2}$  inches. Weight,  $6\frac{3}{4}$  lbs. Operates on 110 volts A.C. or D.C.

Complete, with five-foot connecting cord and full operating directions .....\$12.00

**235H. Steam Engine, Double Cylinder Type, Electrically Heated.** Equivalent to two No. 234H engines mounted on a common base with double the heating capacity and double the power. Has two cylinders, separate throttles, two fly-wheels, water-gauges, stacks, safety valves and one whistle. A powerful



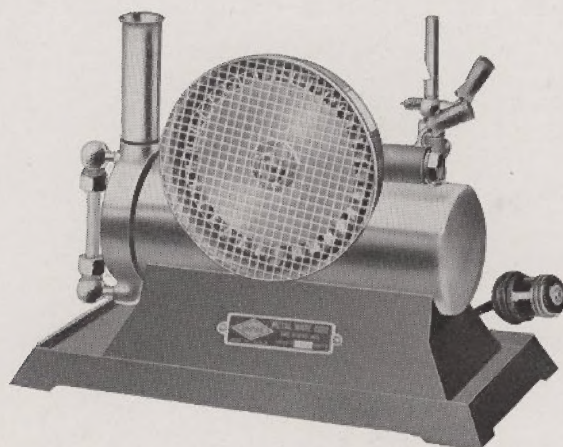
No. 235H.

engine that will operate larger devices than the single cylinder type. Current consumption, 600 watts. Size,  $9\frac{1}{4} \times 8\frac{1}{2} \times 7\frac{1}{2}$  inches. Weight,  $12\frac{1}{4}$  lbs. Operates on 110 volts A.C. or D.C.

Complete, with five-foot connecting cord and full operating directions .....\$25.00



## New Engine Models—Electrically Heated—Cont.



No. 236H.

**236H. Steam Engine, Turbine Type, Electrically Heated.** This engine follows the latest development in steam power plants. It is a miniature duplicate of large single-phase steam turbines, and develops a fascinating natural turbine hum. Unexcelled for speed. Similar to No. 234H steam engine with the exception of generating mechanism. Equipped with hand-operated throttle for regulating speed, whistle for testing steam pressure, safety blow-off valve, water gauge, seamless drawn copper boiler, heavy cast base and accurately machined brass running parts with steel connections. Base, generating mechanism, throttle handle, and whistle handle finished in bright red enamel; other parts, nickel plated. Current consumption, 400 watts. Size,  $9\frac{1}{4} \times 5\frac{3}{4} \times 7\frac{1}{4}$  inches. Weight,  $6\frac{1}{2}$  lbs. Operates on 110 volts A.C. or D.C.

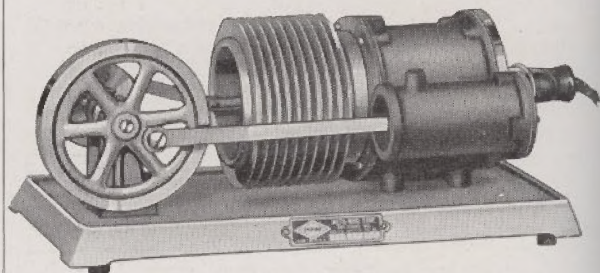
Complete, with five-foot connecting cord and full directions .....\$10.00

### Operating Directions for Models Nos. 234H, 235H, and 236H.

Unscrew stack and fill boiler three-fourths full of water, as indicated by the gauge glass. Replace stack and make connection to a 110-volt (either A.C. or D.C.) lamp socket. After the lapse of five minutes, and occasionally thereafter, test the steam pressure by moving the handle of the steam whistle. When maximum pressure has been developed, as indicated by the escape of steam through the blow-off valve in the stack, open the throttle and give the fly-wheel a slight turn to start it going. Vary the speed by moving the throttle handle, which regulates the flow of steam into the steam chest or turbine generating mechanism. Oil the moving parts before using and empty the boiler after using to insure the best results and longest period of satisfactory service.

**237H. Hot Air Engine, Electrically Heated.** An interesting application of the expansion of gases (in this case air). A loose-fitting plunger shifts the air back and forth in the large cylinder, which is heated at one end and cooled by radiating fins at the other. An opening, or passage, near the closed end of the small or working cylinder, communicates with the heated end of the large cylinder. When the large piston moves down, the hot air below is transferred to the top, where it is cooled and thereby made to contract. The small piston is then forced down by the external pressure of the atmosphere. As soon as this small piston is near the bottom of its stroke the large piston is raised, causing the air to flow back under this large piston, where it is again heated. This makes it expand, forcing the small piston up again, and then the cycle is repeated. This new model develops unusual power and will run for hours without attention, only an occasional oiling. Assembled on heavy cast base. Has accurately machined brass running parts with steel connections. Base and fly-wheel spokes finished in bright red enamel; other parts nickel-plated. Current consumption, 350 watts. Size,  $12 \times 6 \times 5\frac{3}{4}$  inches. Weight, 11 lbs. Operates on 110-volts A.C. or D.C. Starts instantly—no delay.

Complete, with five-foot connecting cord and directions .....\$15.00



No. 237H.